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DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993

HEARINGS

BEFORE THE

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

ON

S. 1507

AUTHORIZING APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993 FOR MILITARY ACTIVITIES OF THE DEPARTMENT OF DEFENSE, FOR MILITARY CONSTRUCTION, AND FOR DEFENSE ACTIVITIES OF THE DEPARTMENT OF ENERGY, TO PRESCRIBE PERSONNEL STRENGTHS FOR SUCH FISCAL YEARS FOR THE ARMED FORCES AND FOR OTHER PURPOSES

PART 5
DEFENSE INDUSTRY AND TECHNOLOGY

APRIL 16, 25; MAY 7, 15, 21 1990

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DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993

TUESDAY, APRIL 16, 1991

U.S. SENATE,
SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

DEFENSE INDUSTRIAL BASE

The subcommittee met, pursuant to notice, at 9:34 a.m. in room SR-222, Russell Senate Office Building, Senator Jeff Bingaman (chairman of the subcommittee) presiding.

Committee members present: Senators Bingaman, Smith and Coats.

Professional staff members present: John J. Hamre and William H. Smith.

Minority staff members present; Romie L. Brownlee, deputy staff director for the minority; Jonathan L. Etherton, professional staff member.

Staff assistants present: Elizabeth Ann Harlow and Camden Jones.

Committee members' assistants present: John P. Gerhart, assistant to Senator Bingaman; Jefferson B. Seabright, assistant to Senator Wirth; Eric H. Thoemmes, assistant to Senator Coats; and Thomas L. Lankford, assistant to Senator Smith.

OPENING STATEMENT OF SENATOR JEFF BINGAMAN, CHAIRMAN

Senator BINGAMAN. The hearing will come to order. The subcommittee meets today to receive testimony on the health and the future of the defense industrial base. We want to explore several trends in defense technology and the defense industry that will shape the effectiveness of our defense industrial base over the next decade.

These trends include five items. First, cuts in defense spending that are expected in this decade. Second, the increased overlap at the technology level between commercial and military sectors, evidenced in the Department of Defense critical technologies plans released in the last 2 years and the Department of Commerce Emerging Technologies Report of last year. Third, a tendency for many of these dual-use technologies to first be applied in the commercial sector for commercial markets to substantially dwarf the defense marketplace. Fourth, the globalization of high technology industry.

Finally, as a corollary to that globalization, the growing and potentially alarming reliance and dependence on foreign sources for many of our critical military components without really an awareness of whether or not these dependencies constitute a threat to our national security.

While these trends are related and, to some extent, reinforcing, there is no simple solution that will take each trend into account and provide a resolution of the overall problem. Despite the fact that they all point to a greater integration of the commercial and military sectors, there is an institutionalized gulf in the development of U.S. commercial and military technologies between the two.

In the aftermath of the collapse of the Warsaw Pact and the successful military actions in the Persian Gulf, we have seldom been in a stronger global position militarily relative to much of the world. Yet it is apparent that there are real questions about the future of our industrial base and questions that we need to confront.

As the two critical technologies plans for the last 2 years pointed out, many of the technologies most important to national security are "dual-use" technologies. They have applications both in the defense sector and the commercial sector; and it is clear that, as the defense budget decreases over the next 5 years, this trend will be even more pronounced.

I believe it is fair to say that the United States cannot maintain an adequate defense industrial base or an adequate commercial industrial base if we keep those two separate. Only a single industrial base for the nation and the strength of that is the key to maintaining the strength of our country. Yet, unfortunately, our defense acquisition system seems geared to maintaining a break between defense and commercial technology that allows us to neither utilize the private sector advances for defense nor leverage the defense resources that we are spending toward improving our commercial technologies.

Today, we have several distinguished witnesses. The first panel consists of Dr. Jacques Gansler and Mr. Bernard Schwartz. Dr. Gansler is the former Deputy Assistant Secretary of Defense, and is currently Senior Vice President of The Analytic Sciences Corporation (TASC) and a Visiting Scholar at Harvard's Kennedy School of Government. Dr. Gansler, in conjunction with the Center for Strategic and International Studies, has recently completed a study entitled, *Integrating Commercial and Military Technologies for National Strength.* Bob Kupperman, who is here today, and I cochaired that study with him. I think it is an excellent contribution to the dialogue and the national debate that needs to take place on what to do about our defense industrial base. The study is being released this morning, and we are very pleased that Dr. Gansler is here to present the findings.

Also on this panel is Mr. Bernard Schwartz who is Chairman and CEO of The Loral Corporation. He is a member of the Defense Policy Advisory Committee on Trade, and he has thought a great deal about the state of our defense industry and how we would deal with the globalization of high tech industry and the increasing integration of the military and commercial sectors, at least at the technology level.

[The prepared statement of Senator Bingaman follows:]

PREPARED STATEMENT OF SENATOR JEFF BINGAMAN

The subcommittee meets today to receive testimony on the health and future of the defense industrial base.

The subcommittee will explore several trends in defense technology and the defense industry that will shape the structure and effectiveness of the defense industrial base over the next decade. These trends include:

(1) Deep cuts in defense spending over the next decade;

(2) An increasing overlap at the technology level between the commercial and military sectors, evidenced in last year's Department of Defense Critical Technologies Plan and Department of Commerce Emerging Technologies Report.

(3) A tendency for many of these dual-use technologies to be applied first in the commercial sector and for commercial markets to dwarf the defense market place;

(4) The globalization of high-technology industry;

(5) And as a corollary of the above, a growing and potentially alarming reliance on foreign sources for critical military components, without an awareness of whether or to what degree these dependencies constitute a threat to our national security.

While these trends are related, and to a certain extent, mutually reinforcing, there is no silver bullet that will take each trend into account and provide a simple solution. And despite the fact that they all point toward a greater integration of the commercial and military sectors, there is an institutionalized gulf in the development of U.S. commercial and military technologies.

In the aftermath of the collapse of the Warsaw Pact and successful military action in the Persian Gulf, we as a nation have rarely been in such a strong global position. Yet it is apparent that we are also at a global crossroads, where the future of our industrial base is in question on many fronts.

As each of the two annual Defense Critical Technologies Plans has pointed out, many of the technologies most important to national security are "dual-use" technologies, with applications in both the defense and commercial sectors. It is clear that as the defense budget decreases over the next 5 years this trend will become more pronounced. Already most of the advances made in dual-use technologies are being made in the commercial sector, and increasingly those advanced technologies are first being applied by foreign companies.

I believe it is fair to say that the United States cannot maintain a separate defense industrial base and commercial industrial base; there is only the Nation's industrial base, and the strength of base is a key to the strength of our country. Yet our defense acquisition system seems geared to maintaining a break between defense and commercial technology that allows us to neither utilize private sector advances for defense nor leverage defense resources toward more advanced commercial technologies that the United States could draw on for advanced weaponry.

As we are forced to rely more on commercial technology, our traditional "hands-off" approach to commercial technology development and application in the United States leaves us dependent on foreign companies for many critical components. The Department of Defense does not seem to be able to identify either the extent of our dependency or to identify what dependencies might constitute a threat to national security. At a hearing held by this subcommittee last week, Assistant Secretary Colin McMillan stated that the United States is not dependent on foreign technology, merely reliant on certain foreign technologies. I look forward to exploring this concept of "reliance" versus "dependence" in greater depth today.

It seems clear that neither the "laissez-faire approach," nor the "arsenal of democracy approach" will guarantee us the strong industrial base that is required now to develop and field weapons in the future. The real world is actually a messy gray area that lies in between these two extremes, and the U.S. will need to address these issues realistically over the next few years if we are to maintain our military capability.

In my view, the Persian Gulf conflict underscores the fact that the way we planned for the defense industrial base in the past is fast becoming obsolete. I believe that, given the changing nature of the security threat and reduced defense resources, DOD must develop an effective, coordinated approach to maintaining an industrial base that will be able to draw upon developments in the commercial sector and meet our defense needs.

Hopefully we will address the problems as well as possible approaches to solutions in today's hearing.

This morning we will hear testimony from four distinguished witnesses.

Our first panel consists of Dr. Jacques Gansler and Mr. Bernard Schwartz. Dr. Gansler is the former Deputy Assistant Secretary of Defense, and is currently Senior Vice President of The Analytical Sciences Corporation (TASC) and a Visiting Scholar at Harvard's Kennedy School of Government. Dr. Gansler, in conjunction with the Center for Strategic and International Studies (CSIS), has recently completed a study entitled *Integrating Commercial and Military Technologies for National Strength*. Many of those in the audience today are aware that I was a co-chair of this study with Dr. Gansler and Robert Kupperman, Director of the CSIS Arms Control, Science and Technology Program. The study is being released this morning, and I am pleased to have Dr. Gansler here to present its findings.

Our second witness is Mr. Bernard Schwartz, Chairman and CEO of the Loral Corporation. Mr. Schwartz is a member of the Defense Policy Advisory Committee on Trade, and has thought a great deal about the state of our defense industry and how we should deal with the globalization of high-tech industry and the increasing integration of the military and commercial sectors, at least at the technology level.

Our second panel consists of Mr. Paul F. Math and Mr. Nicholas M. Torelli. Mr. Math is the Director for Research, Development, Acquisition, and Procurement Issues for the National Security and International Affairs Division of the General Accounting Office. The GAO recently submitted a study done at my request entitled *Industrial Base: Significance of DOD's Foreign Dependence*, and Mr. Math will testify this morning on the results of that study as well as possible approaches to addressing the questions raised by foreign dependency.

Mr. Nic Torelli is the Deputy Assistant Secretary of Defense for Production Resources. He has responsibility for policy development and implementation and oversight of weapons systems production resources, including industrial engineering and quality, manufacturing modernization, and the industrial base. Mr. Torelli will testify this morning on the Department's efforts to better integrate commercial products into defense systems.

Before we begin, I would ask if the distinguished ranking member, Senator Coats, has any opening remarks he would like to make.

Senator BINGAMAN. Why don't we begin with Mr. Schwartz's testimony followed by Dr. Gansler, and then we will have a few questions for this panel before we begin the second panel. Thank you very much for being here.

STATEMENT OF BERNARD L. SCHWARTZ, CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, THE LORAL CORPORATION

Mr. SCHWARTZ. Thank you, Mr. Chairman. I am Bernard Schwartz, Chairman and Chief Executive Officer of Loral Corporation. I welcome the opportunity this morning to appear before the subcommittee to discuss the precarious state of the defense industrial base and the health of the U.S. defense industry.

In recent years, I have become increasingly concerned about the erosion of our defense industrial base in my capacity at Loral and, also, as a member of the Executive Committee of the Defense Policy Advisory Committee on Trade. I want to emphasize at the outset that the views which I present here today are my own and do not necessarily represent those of any organization.

The recent Gulf war reminds us that the world is not a perfect place. Aggression, despotism, injustice, national expansionism were not invented with the Russian Revolution in 1917, nor are they banished with the crumbling of the Berlin Wall. Tribalism, religious fundamentalism, nationalism and power-hungry ambitions will continue to cause regional conflicts that threaten the peace and stability of the world, which in turn may threaten America's national security interests.

Some of these threats will take the form of a military challenge, and we must invest our defense resources in conventional forces to meet these regional conflicts. Simultaneously, we must recognize the decreased threat from superpower conflicts.

On the one hand, this will provide an opportunity to down-size our national defense structure, providing needed resources to mend our societal and economic infrastructure. On the other hand, we need to protect our defense industrial base to support a mobile, tactical, high-tech military capable of answering the challenges of the new global geo-politics of the future.

Accordingly, the United States Government has a vital interest in the health of the defense industrial base and a real role to play in its return to health. And the industry base to which I refer includes both the large, prime contractors as well as the essential corps of subcontractors whose technical innovations and entrepreneurialism are the distinguishing strengths of America's industry. The kind of world leadership and statesmanship exhibited by the United States during the entire Gulf crisis is only possible if they are backed up by a strong military presence. Without it, diplomacy cannot succeed.

Unfortunately, our defense industry has been damaged by a host of factors including onerous DOD procurement practices, overlapping and confusing oversight, the inconsistency of annual funding, the uncertainty of recoupment of R&D and program investments, and price-only criteria for production awards. These have contributed to an alarming reduction in the industry's investment returns, which in turn depressed market values and the ability to raise capital. These developments have substantially weakened the industry. It is indeed an irony that at the moment our weapons are the world's envy, the industry that produced them is badly damaged.

Some of our difficulties were of the industry's own making. We were late on total quality management and compliance, and too often we invested in programs that we should have known were technically unachievable given the time and financial constraints. But much of the problem has been caused by the government's disregard of the cumulative negative impact of changes affecting the industry.

There is a critical bilateral responsibility between the defense industry and the U.S. Government to work as partners to produce the world's finest weapon systems. However, when the customer's only procurement goal is to buy products at the cheapest price, the scales tip against the health of the industry.

This is especially true in our industry because we have only one customer who dictates what he will buy, when he will buy it and what he will pay for it and whom else we can sell it to. This customer also properly demands on-time performance, reliability, quality, dependability and leading edge technology. However, when price is the only measurement for award, the bilateral responsibility and mutual dependency are weakened and procurement becomes a killing field to the viability of our industry.

Notwithstanding the psychological boost from Desert Storm, the report card on our industry's financial health is dismal. In 1990 alone, U.S. defense contractors wrote off more than $2 billion from losses on fixed-price contracts and corporate restructurings. Over the last 5 years, defense industry stocks have lost 40 percent of their market value. Our price/earnings ratio is about half that of the Standard and Poor 400, and lenders are starting to redline our industry.

Over the same period, defense industry debt grew by 81 percent while earnings dropped by 45 percent. A significant source of industry financing was the completed contract method of accounting. This advantage was eliminated, and at the same time, progress payments were lowered. Industry debt grew by 81 percent while earnings dropped by 45 percent.

All of these adverse changes were imposed on the industry while the business base and the DOD budget were in decline. The result—the average internal rate of return for our industry is 6.6 percent, the average cost of capital between 10 and 12 percent. In a purely financial sense, those companies which invested billions of dollars in the country's next generation defense capability would have been better off to put their money into long-term government securities.

Despite the phenomenal success of our equipment in Desert Storm and an expanded market for U.S. defense exports, the industry's prospects have not fundamentally improved. While we expect Desert Storm replacement orders, defense budget cuts will overwhelm this and any pick-up in foreign sales. The success of our equipment will eventually increase order input, but the effect will be spread over many years. Moody's predicts further cash flow squeezes, declining profitability, dividend cuts, layoffs and consolidations. Losses stemming from ill-conceived and poorly-executed fixed-price development contracts will continue to degrade industry profitability for years.

At the same time, we are shackled by over-regulation and oversight which have changed the acquisition climate from cooperative to adversarial. ACO's, administrative contracting officers, the business end of the government procurement structure, have been replaced by auditors in the management of programs. Program tradeoffs and business negotiations are a thing of the past. I cannot hire auditors and lawyers fast enough, while at the same time I am forced to lay off scientists and engineers. This trend does not bode well for the future of our technology base.

Not surprisingly, firms are leaving our industry in droves—victims of diminishing returns, financial failure, foreign predators or an unwillingness to cope with the expense and rigors of federal contracting. Some of the good-performing, highly respected companies are also leaving. They have the financial resources and managerial skills necessary to enter new, non-military markets, leaving perhaps poorer and weaker companies to meet this country's defense needs.

We cannot afford to let this random process, often motivated by short-term considerations, dictate who will survive. For national security reasons, the reshaping of this industry must not be left to accidental market forces.

I am most certainly not talking about the government picking winners and losers. I do not propose de-emphasizing competition. Competition has been good for the industry and good for the government. Nor am I talking about a protective, "good old boy" network that papers over inefficiency or poor performance. We have, fortunately, progressed past that point. I am talking about emphasizing incentives for good performance and reintroducing fairness and stability to the military contracting community.

On another important issue, an array of industry and government executives have warned about the dangers of selling our high technology defense industrial base to foreign owners. They also warned of the longer-term risks of losing sovereignty over our defense production capability and, more importantly, over the R&D resources so desperately needed by the United States to maintain our technological superiority. Once ownership control moves offshore, our national security interests may not be well served.

The issue of such foreign ownership is one of control. The ultimate authority over the allocation of resources and operations may reside in the stock ownership or in the majority of the board of directors or the chief executive officer. The answer must be determined on a case-by-case basis. I believe there are sufficient protections in place to insure, when appropriately applied, against the transfer of critical technology or production capability to foreign control. It requires, however, heightened national security concern for the risks involved in offshore purchases of U.S. companies.

Free market enthusiasts label any effort to preserve our national defense assets as either protectionism or industrial policy. I wonder where these theorists were during Operation Desert Storm when we were forced to go to companies in Italy, Japan and the U.K. to secure critical components for search and rescue radios and navigation systems, video panels and cockpit displays, to name just a few items. Overall, as I understand it, there were over 30 instances where we required the vigorous intervention of national governments to persuade foreign controlled companies to cooperate with the United Nations coalition. On the other hand, the U.S. Government enjoyed 100 percent unconditional support from its U.S. suppliers.

Today's allies may be tomorrow's antagonists and vice versa, so it would be foolish to depend on foreign cooperation in the future.

The government can take several steps to insure that the United States' defense industrial base remains healthy and American security interests are protected. I am not speaking of increasing DOD budgets or subsidizing unneeded capacity. What we do need is a more balanced and constructive environment with accountability for meeting commitments, with appropriate risk-sharing for technology development, and with rewards for good performance.

First, Congress and the Defense Department need to be much more supportive of defense industry export efforts. The proposed Export-Import bank loan guarantees that Congress is now considering for defense products is a useful first step. Efforts such as this will allow the U.S. defense industry to compete more effectively against our heavily subsidized foreign competitors.

Second, we should vigorously resist international weapons consortia whose agreements are written to specifically exclude American participation. I expect that Europe '92 will become Fortress Europe with many American firms precluded from participating in American overseas defense programs such as the European fighter.

And the same may become true in Japan as it procures more defense-oriented technologies. The U.S. Government needs to make its views on such exclusionary practices known in an aggressive manner.

Third, changes should be made in the U.S. tax laws to actively encourage private investment in defense companies. The single most important change would be to foster the availability of low-cost capital by eliminating the capital gains tax or by deferring taxes on realized profits which are then reinvested in emerging high-tech companies. We should shorten depreciation schedules for high-tech capital equipment and exempt certain high tech consortia from antitrust regulations. We should also make R&D tax credits permanent.

On a more encouraging note, the DOD is considering a provision to increase progress payments by 5 percent effective July 1 of this year. Both symbolically and substantively, this is an important step towards restoring health to the industry and fairness to the procurement process. It bodes well for future cooperation between industry and government, and I urge you in the Senate to support this change.

Currently, there is a series of financial disincentives peculiar to the defense industry that, if abolished, would dramatically increase the attractiveness of private investment in leading edge defense technology. For example, there is a new provision in the Federal Acquisition Regulations that does not allow defense companies to recover the fair market value paid for valuable defense assets in an acquisition. This constitutes a powerful poison pill for any potential U.S. purchaser of a U.S. defense company.

Additionally, the DOD only allows a portion of a contractor's own investment in research and development and the interest expense associated with the investment as a recoverable cost. If 100 percent of all defense R&D could be recovered, treated similarly as other operating costs are, I am sure you would see a marked increase in R&D investments.

At the heart of every industrial base report is a recurring theme: keeping the defense industry healthy, efficient and competitive requires predictable federal budget support. And therein lies another area where Congress can help.

It is tough to intelligently manage a defense company when, each year, programs to which we have dedicated millions of dollars and countless people are slipped to the right, stretched out, put on hold, cut back, defunded, descoped, rescoped, canceled and reinstated, dead one day and back again the next. These swings discourage long-term investments in new technology and capital. For some, this may be a matter of politics as usual, but for the defense industry it is a matter of life and death. Multi-year procurements would offer welcome relief.

It has been suggested that the integration of military and nonmilitary activities and the dual use of technology and production will provide tangible relief to our beleaguered industry. I am not hopeful that this will provide a practical solution. Government pricing, costing and accounting policies impose considerable administrative and operational difficulties to integrating defense technology into commercial, industrial or consumer products. In addition, there are disincentives in the application of mil spec standards and the protection of technical data rights.

In a practical sense, I would not expect Loral Corporation, for example, with our defense culture, to effectively compete against companies widely experienced in the manufacture, merchandising and distribution of commercial products. Only in very limited circumstances will the economic benefits overcome the expense of conversion. I do not see many managements stepping up to the risks involved. Further, I see no tangible evidence that the government is truly committed to offer sufficient incentives.

Before concluding, I would like to address the recent proposal which recently advocated that it is sufficient to fund technology R&D without the accompanying production. This would dangerously shrink our production base for military products and under-estimates the interdependence between production and engineering. R&D not translated into production is pure science, lacking the vitality of application. Defense capability requires production technology and a cadre of experienced technicians to meet our national security requirements.

A key ingredient of Loral's success in this business is our expertise to design for production and to produce what we design. Our engineering creativity does not end with the beginning of production. Emphasis on value engineering to make the product smaller, with more power and less costly continues throughout its manufacture through our comprehensive pre-planned product improvement efforts. The positive impact that manufacturing has on engineering cannot be under-estimated.

In each of the two major wars of this century, the United States experienced the luxury of others fighting the early battles while we stoked up our production. That luxury may not be available next time. In fact, the United States may not have a decade to produce the hardware or 6 months to transport it to the theater of operations in the next Desert Storm.

In conclusion, Mr. Chairman, may I observe that industry and government are responsible together as partners for the thoughtful guidance and planned shaping of our industrial base. I believe it is a responsibility which the Senate is advancing by hearings such as this one, and I particularly want to express my appreciation to you, Senator Bingaman, for your continuing efforts in furthering this dialogue.

Thank you.

[The prepared statement of Mr. Schwartz follows:]

PREPARED STATEMENT BY BERNARD L. SCHWARTZ, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, LORAL CORPORATION

Mr. Chairman and members of this distinguished subcommittee, I am Bernard L. Schwartz, Chairman and Chief Executive Officer of Loral Corporation.

I welcome the opportunity to appear before you today to discuss the precarious state of the defense industrial base and the health of the U.S. defense industry.

In recent years, I have become increasingly concerned about the erosion of our defense industrial base in my capacity at Loral and also as a member of the executive committee of the Defense Policy Advisory Committee on Trade. I want to emphasize at the outset that the views which I present today are my own and do not necessarily represent those of any organization.

The recent Gulf war reminds us that the world is not a perfect place. Aggression, despotism, injustice, national expansionism were not invented with the Russian revolution in 1917, nor are they banished with the crumbling of the Berlin Wall. Tribalism, religious fundamentalism, nationalism and power-hungry ambitions will continue to cause regional conflicts that threaten the peace and stability of the world, which in turn may threaten America's national security interests.

Some of these threats will take the form of a military challenge, and we must invest our defense resources in conventional forces to meet these regional conflicts. Simultaneously, we must recognize the decreased threat from superpower conflicts.

On the one hand, this will provide an opportunity to downsize our defense structure, providing needed resources to mend our societal and economic infrastructure. On the other hand, we need to protect our defense industrial base to support a mobile, tactical, high-tech military, capable of answering the challenges of the new global, geo-politics of the future.

Accordingly, the U.S. Government has a vital interest in the health of the defense industrial base and a real role to play in its return to health. And the industry base to which I refer includes both the large prime contractors as well as the essential corps of subcontractors whose technical innovations and entrepreneurialism are the distinguishing strengths of America's industry.

The kind of world leadership and statesmanship exhibited by the United States during the entire Gulf crisis are only possible if they are backed up by a strong military presence. Without it, diplomacy cannot succeed.

Unfortunately, our defense industry has been damaged by a host of factors including onerous DOD procurement practices, overlapping and confusing oversight, the inconsistency of annual funding, the uncertainty of recoupment of R&D and program investments, and price—only criteria for production awards. These have contributed to an alarming reduction in the industry's investment returns, which in turn depress market values and the ability to raise capital.

These developments have substantially weakened the industry. It is indeed an irony that at the moment our weapons are the world's envy, the industry that produced them is badly damaged.

Some of our difficulties were of the industry's own making—we were late on total quality management and compliance, and we too often invested in programs that we should have known were technically unachievable given the time and financial constraints. But much of the problem was caused by the government's disregard of the cumulative negative impact of the changes on the industry.

There is a critical bilateral responsibility between the defense industry and the U.S. Government to work as partners to produce the world's finest weapons systems.

However, when the customer's only procurement goal is to buy products at the cheapest price, the scales tip against the health of the industry. This is especially true in our industry because we have only one customer who dictates what he will buy, when he will buy it, what he will pay for it and who else we can sell it to. This customer also *properly* demands on-time performance, reliability, quality, dependability and leading edge technology. However, when price is the only measurement for award, the bilateral responsibility and mutual dependency are weakened and procurement becomes a killing field to the viability of our industry.

Notwithstanding the psychological boost from Desert Storm, the report card on our industry's financial health is dismal. In 1990 alone, U.S. defense contractors wrote off more than $2 billion from losses on fixed-price contracts and corporate restructurings.

Over the last 5 years, defense industry stocks have lost 40 percent of their market value, our price/earnings ratio is about half that of the S&P 400, and lenders are starting to redline our industry. Over the same period, defense industry debt grew by 81 percent, while earnings dropped by 45 percent. A significant source of industry financing was the completed contract method of tax accounting; this advantage was eliminated. And at the same time, progress payments were lowered.

All of these adverse changes were imposed against the industry while the business base, the DOD budget, was in decline.

Result: average internal rate of return for our industry is 6.6 percent; average cost of capital between 10–12 percent.

In a purely financial sense, those companies which invested billions of dollars in this country's next generation defense capability would have been better off to put their money in long-term government securities.

Despite the phenomenal success of our equipment in Desert Storm and an expanded market for U.S. defense exports, the industry's prospects have not fundamentally improved. While we expect Desert Storm replacement orders, defense budget cuts will overwhelm this and any pick-up in foreign sales. The success of our equipment will eventually increase order input, but the effect will be spread over many years.

Moody's predicts further cash flow squeezes, declining profitability, dividend cuts, layoffs and consolidations. Losses stemming from ill conceived and poorly executed fixed-price development contracts will continue to degrade industry profitability for years.

At the same time, we are shackled by over-regulation and oversight which has changed the acquisition climate from cooperative to adversarial. ACO's (administrative contracting officers), the business end of the government procurement structure, have been replaced by auditors (the DCAA) in the management of programs. Program trade-offs and business negotiations are a thing of the past. I cannot hire auditors and lawyers fast enough, while at the same time I am forced to lay off scientists and engineers. This trend does not bode well for the future of our technology base.

Not surprisingly, firms are leaving our industry in droves—victims of diminishing returns, financial failure, foreign predators, or an unwillingness to cope with the expense and rigors of federal contracting. Some of the good performing, highly respected companies are also leaving. They have the financial resources and managerial skills necessary to enter new nonmilitary markets, leaving perhaps poorer and weaker companies to meet this country's defense needs.

We can't afford to let this random process, often motivated by short-term considerations, dictate who will survive: for national security reasons the reshaping of this industry must not be left to accidental market forces.

But I am most certainly not talking about the government picking winners and losers. I do not propose de-emphasizing competition. Competition has been good for the industry and good for the government. Nor am I talking about a protective good old-boy network that papers over inefficiency or poor performance. We have, fortunately, progressed past that point. I am talking about emphasizing incentives for good performance, and reintroducing fairness and stability to the military contracting community.

On another important issue, an array of industry and government executives have warned about the dangers of selling our high technology defense industrial base to foreign owners. They also warned of the longer term risks of losing sovereignty over our defense production capability, and, more importantly, over the R&D resources so desperately needed by the United States to maintain our technological superiority. Once ownership control moves offshore, our national security interests may not be well served.

The issue of such foreign ownership is one of control. The ultimate authority over the allocation of resources and operations may reside in the stock ownership, or in the majority of the board of directors, or the chief executive officer. The answer must be determined on a case by case basis. I believe there are sufficient protections in place to ensure, when appropriately applied, against the transfer of critical technology or production capability to foreign control. It requires, however, heightened national security concern for the risks involved in offshore purchases of U.S. companies.

Free market enthusiasts label any effort to preserve our national defense assets as either protectionism or industrial policy. I wonder where these ivory tower theorists were during operation Desert Shield when we were forced to go to companies in Italy, Japan and the U.K. to secure critical components for search and rescue radios and navigation systems, video panels and cockpit displays, to name just a few. Overall, as I understand it, there were over 30 instances where we required the vigorous intervention of national governments to persuade foreign controlled companies to cooperate with the U.N. coalition. On the other hand, the U.S. Government enjoyed 100 percent unconditional support from its U.S. suppliers. Today's allies may be tomorrow's antagonists and vice versa, so it would be foolish to depend on foreign cooperation in the future.

Until we receive significant relief from the maze of harmful procurement and legislative policies, the defense industrial base of the United States will continue its decline. Soon, we may pass the point of no return when we have either starved or destroyed or disposed of our defense assets.

This country is not well served by an industry that is bloated, lazy or sloppy; but neither will we be well served by an industry that is battered, beleaguered and bankrupt. The harvest of all those punitive actions is an industrial base that is no longer resilient, vital or easily recoverable.

First, the government can take several steps to ensure that the U.S. defense industrial base remains healthy, and American security interests are protected. I am not speaking of increasing DOD budgets or subsidizing unneeded capability. What we do need is a more balanced and constructive environment with accountability for meeting commitments, with appropriate risk sharing for technology development, and with rewards for good performance.

Congress and the Defense Department need to be much more supportive of defense industry export efforts. The proposed export-import bank loan guarantees that Congress is now considering for defense products is a useful first step. Efforts such as this will allow the U.S. defense industry to compete more effectively against our heavily subsidized foreign competitors.

Second, we should vigorously resist international weapons consortia whose agreements are written to specifically exclude American participation. I expect that Europe '92 will become fortress Europe, with many American firms precluded from participating in important overseas defense programs, such as the European fighter. And the same may become true in Japan as it procures more defense-oriented technologies. The U.S. Government needs to make its views on such exclusionary practices known in an aggressive manner.

Third, changes should be made in U.S. tax laws to actively encourage private investment in defense companies. The single most important change would be to foster the availability of low cost capital by eliminating the capital gains tax or by deferring taxes on realized profits which are then reinvested in emerging high-tech companies. We should shorten depreciation schedules for high-tech capital equipment and exempt certain high-tech consortia from antitrust regulations. We should also make R&D tax credits permanent.

On a more encouraging note, the DOD is considering a provision to increase progress payments by 5 percent effective July 1. Both symbolically and substantively, this is an important step toward restoring health to the industry and fairness to the procurement process. It bodes well for future cooperation between industry and government. I urge you in the Senate to support this change.

Currently there is a series of financial disincentives peculiar to the defense industry that, if abolished, would dramatically increase the attractiveness of private investment in leading-edge defense technology. For example, there is a new provision in the Federal Acquisition Regulations that does not allow defense companies to recover the fair market value paid for valuable defense assets in an acquisition—a powerful poison pill for any potential U.S. purchaser of a U.S. defense company. This may well result in a big incentive to sell defense companies to foreign interests.

Additionally, the DOD only allows a portion of a contractor's own investment in research and development, and the interest expense associated with the investment, as a recoverable cost. If 100 percent of all defense R&D could be recovered, treated similar to other operating costs, I am sure you would see a marked increase in R&D investments by defense contractors.

At the heart of every industrial base report is a recurring theme: keeping the defense industry healthy, efficient, and competitive requires predictable Federal budget support. And therein lies another area where Congress can help.

It is tough to intelligently manage a defense company when *each year* programs to which we have dedicated millions of dollars and countless people, are slipped to the right, stretched out, put on hold, cutback, de-funded, re-scoped, de-scoped, canceled and reinstated—dead one day, back again the next. These wild swings discourage long-term investment in new technology and capital. For some this may be a matter of politics as usual, but for the defense industry, it is a matter of life or death. Multi-year procurements would offer welcome relief.

It has been suggested that the integration of military and non-military activities and the dual use of technology and production will provide tangible relief to the beleaguered defense industry. I am not hopeful that this will provide a practical solution.

Government pricing, costing and accounting policies impose considerable administrative and operational difficulties to integrating defense technology into commercial, industrial or consumer products. In addition, there are disincentives in the application of mil-spec standards and the protection of technical data rights.

In a practical sense, I would not expect Loral Corporation, with our defense culture, to effectively compete against companies widely experienced in the manufacture, merchandising and the distribution of commercial products. Only in very limited circumstances will the economic benefits overcome the expense of conversion. I do not see many managements stepping up to the risks involved. Further, I see no tangible evidence that the government is truly committed to offer sufficient incentives. I doubt that many managements will regard the rewards worthy of the risks off such integration.

Before concluding, I'd like to address the proposal, recently advocated, that it is sufficient to fund technology R&D without the accompanying production. This would dangerously shrink our production base for military products and underestimates the interdependence between production and engineering. R&D not translated into production is pure science, lacking the vitality of application. Defense capability requires production technology and a cadre of experienced technicians to meet our national security requirements. A key ingredient of Loral's success in this business is our expertise to design for production and to produce what we design. Our engineering creativity does not end with the beginning of production; emphasis on value engineering to make the product smaller, with more power, less costly—continues throughout its manufacture through our comprehensive pre-planned product improvement (P3I) efforts. The positive impact that manufacturing has on engineering cannot be underestimated.

In each of the two major wars of this century, the United States experienced the luxury of others fighting the early battles while we stoked up our production. That luxury may not be available next time. In fact, the United States may not have a decade to produce the hardware, or 6 months to transport it to the theater of operations in the next Desert Storm.

In conclusion, may I observe that industry and government are responsible, together, as partners for the thoughtful guidance and planned shaping of our industrial base. I believe it is a responsibility which the Senate is advancing by hearings such as this one, and I particularly want to express my appreciation to you, Senator Bingaman, for your continuing efforts in furthering this dialogue with industry.

Thank you, and I am prepared to answer any of your questions.

Senator BINGAMAN. Thank you very much. Before we go to any questions, why don't we go ahead and hear from you, Dr. Gansler, about your report and anything else you would like to tell us.

STATEMENT OF JACQUES S. GANSLER, SENIOR VICE PRESIDENT, THE ANALYTIC SCIENCES CORPORATION (TASC)

Dr. GANSLER. What I would like to do, if I could, is to submit a formal statement for the record and then just summarize it.

Senator BINGAMAN. That's fine. We'll include it all in the record.

Dr. GANSLER. With the spectacular success of Desert Storm now largely behind us, I believe it's essential that the Congress and the Department of Defense confront two major concerns that will be facing them over the next decade. First, how to reduce the cost of defense equipment; and, second, how to maintain a viable defense industrial base: an industrial base that maintains the state of the art capability that it has had in the past and yet keeps costs to a minimum. Additionally, an industrial base that insures a surge of production in any future emergency.

My concern is that, with the likelihood of a reduced defense budget in the coming years, these goals will be difficult if not, in fact, impossible, to achieve under the current weapons acquisition process. In fact, frequently these goals are in conflict. What I would like to discuss today is an alternative approach to traditional defense acquisition practices which exists, and it has the potential to achieve both objectives simultaneously, the objectives of lower cost and of a stronger industrial base overall.

Several distinguished task forces and government commissions on weapons acquisition, such as the Defense Science Board, the Packard Commission and others, have concluded that the solution to this dilemma lies in far greater use of civil-military integration wherever this is appropriate. The benefits would be twofold—a far larger industrial base would be available when it's required for production surge but it would not be dependent on the DOD for economic survival and, second, significantly greater economies of scale and scope that could come through the integration and thus lower costs and higher quality.

Such integration was not possible in the past. At that time, defense technology was usually more advanced in performance and designed for more severe environments than that which is normally experienced in the commercial sector. Moreover, commercial production generally required high volume to achieve the efficiencies, and defense small volume was inconsistent with that. Today, however, high performance, ruggedized commercial product technologies and flexible manufacturing process technologies used by the commercial world have advanced to the point where such civil-military integration is both technologically possible and economically desirable.

Under this alternative approach, the government would maintain only a very few defense-unique sectors in the economy. Those technologies would be specific to defense, and clearly, for example, nuclear weapons fits into that category. In these limited areas, the government must assure that the Nation maintains, or at least has assured access to, some minimum core of engineering and production capability in each of these critical sectors. However, for the rest of its defense equipment needs, the government must work with the commercial sector for research, development, production and support of its requirements and for the direct acquisition of commercial materials, components and equipment.

In this future world, national assets such as technology, facilities and, most important, people would be used to simultaneously enhance both U.S. security and economic competitiveness, ending today's inefficient and artificial division of productive resources according to whether they are military or civilian end users.

Essentially, this vision encompasses, wherever it's applicable, three forms of civil-military integration. First, and perhaps the most driving, is dual-use R&D, developed to common requirements. Second is plant integration, not at the corporate accounting level but actually on the plant floor, of engineering, production and support. And third, the most obvious one, the buying of common, ruggedized equipment. And this is most applicable at the sub-system and component levels. All of these would be made possible by greater reliance on commercial buying practices and commercial specifications and standards.

Such a strategy would require profound change in the regulations and laws that govern DOD procurement and cost accounting as well, and in the design approaches, the specifications and other characteristics that make up the "unique defense acquisition culture." Nevertheless, this strategy provides the best hope for addressing the problems that plague the defense industrial base that Mr. Schwartz so very well annunciated; promises significant cost savings to the DOD at a time of budgetary crisis that we clearly are facing today. It ensures adequate surge capability to meet emergency military requirements and, from a broader perspective, strengthens the science and technology base in the United States because the large amount of DOD R&D would become available.

The achievement of this vision will be difficult. It will take many years, but the time to begin I believe is now. Without such a dramatic change, the U.S. defense industrial base will continue to devolve into a small, highly specialized, highly subsidized, increasingly inefficient sector, a defense industry that may soon be incapable of meeting the nation's fundamental security requirements; namely, adequate quantities of affordable equipment, access to and rapid fielding of cutting edge technologies, and the ability to expand selected production significantly when crisis conditions warrant it.

The problem is that today, the Department of Defense cannot easily reach beyond its captive industrial base. DOD's "business as usual" virtually forces a separation of the private sector into two discrete economies, defense and non-defense.

To address this problem, we established a senior committee of government and industry leaders, and over an 18-month period we performed a detailed set of industry case studies to look at why world class companies separated their operations, even if they were down the street from each other, between commercial and military. We found that, in most companies, defense products are designed, developed, produced and supported in isolated plants or independent divisions. On the research side, many companies either maintain separate research facilities for defense and commercial work, or many simply refuse to accept DOD research contracts. Similarly, most firms create separate engineering and production facilities for military work, a process that duplicates literally billions of dollars in capital and labor investments in the commercial sector.

The segregation of commercial and military work is also reflected in the federal research laboratories. Few of the government laboratories attempt, and many don't even desire, to exploit the growing synergies between military and commercial technologies.

Such separation of U.S. high-technology activities into defense and non-defense sectors has perverse consequences for the Department of Defense. The low volume of defense orders means higher unit costs and, therefore, still fewer systems produced. A diminished industrial base limits the capability for production surge and is increasingly reliant on foreign sources for many critical supplies. The lack of access to commercial industry also means restricted access to state-of-the-art products and production process technologies as well, which are increasingly being developed in the commercial sector first.

From the economic side, the fragmentation of the U.S. high technology sector has an unfavorable impact on our national economic strength. The DOD is the largest single Federal purchaser of advanced R&D, to the extent that its investments cannot easily generate dividends for the commercial sector; 70 percent of the total federal investment in R&D supports only 6 percent of the GNP—an especially important point, as Senator Bingaman pointed out, in light of the extensive overlap between the identified technologies that are critical to Department of Defense and those that are identified by the Department of Commerce as critical emerging technologies.

Moreover, segregation of the military from the commercial sector artificially splits the national pool of human talent. Nearly one-third of all U.S. scientists and engineers are employed in military work, but, even within the same company, scientists and engineers in the commercial and military divisions rarely if at all communicate with each other. Since human contact has been found to be the primary vehicle for technology transfer and, indeed, for innovation, without links between the commercial and defense sectors the pace of innovation in each is slowed dramatically, and both the nation's security and its economic competitiveness suffer.

The traditional argument for this segregation is that defense technologies are unique; no commercial market exists for the products, or the military's requirements far exceed anything the commercial sector can produce. Of course, there's clearly little demand for some defense-unique products such as an MX missile or an M-1 tank. At the same time, the materials, components and sub-systems that make up those systems often have commercial counterparts that are less costly, equal to and, in some cases, more advanced than their defense equivalents, and capable of satisfying similar or even more severe environmental conditions. Additionally, the production process, the technologies utilized are also identical, thus allowing factory level integration even when the final products are very dissimilar. The extreme might be the Russians building railroad cars and tanks in the same plant because the production processes are similar.

Defense technologies are unique largely because of the way the government procures them. Many companies do not segregate their defense business because their commercial lines cannot satisfy DOD's rigorous requirements—not because they are not capable of satisfying the performance requirements, but because the procurement regulations would seriously jeopardize commercial efficiency and profitability.

Our study identified four areas of regulation or legislation as the dominant factors that drive a wedge between commercial and military business. In priority order these were: first, accounting requirements and auditing; second, military specifications and standards; third, technical data rights; and fourth, unique government contract requirements.

In our report, each of these four areas are analyzed in considerable detail in terms of both the barriers to integration and the changes required to remove these barriers. The objective is to create incentives for world class U.S. corporations to integrate their civil and military operations and for the government to encourage these world class companies to seek out business with the government. The findings and recommendations of this report are summarized in my formal submittal so I won't go through those.

I personally believe that these specific recommendations would clearly move the weapons acquisition process in the desired direction. However, the critical need is for some concrete, significant action. Once a commitment to action is made and responsibilities assigned, then each of the various alternatives can be evaluated, perhaps some even tried experimentally, and the process can move forward.

In summary, the defense acquisition system is required to meet many worthy goals: fairness to all bidders, elimination of contractor fraud, attainment of socio-economic benefits from defense spending, and cost efficiency. The problem is that these goals often tend to be incompatible. At times, the emphasis is on fairness, while at other times the goal is efficiency. And, as a result, the procurement system veers erratically between competing objectives without fully realizing any of them. I believe a choice must be made.

The strategy proposed here emphasizes efficiency, innovation and surge responsiveness. Essentially, it is proposed to transform the Department of Defense into a world-class buyer, a buyer able to compete with other world-class buyers for goods of high quality and low cost from a domestic industrial base, one in which commercial and military production is, wherever applicable, fully integrated.

I believe that this integration must be realized. It is this vision of increasing the availability and dual-use utility of the large share of the $38 billion of DOD R&D and a similarly large share of the over $100 billion of DOD procurement and capital investment that will help to stimulate the U.S. domestic industry to be far more competitive, and thus help to reverse the growing trend towards the loss of U.S. international technological competitiveness and the corresponding increase in foreign dependence for the DOD.

To achieve this integration strategy requires, first, a total commitment to change by both the Congress and the DOD and, second, a specific legislative and regulatory agenda for implementation.

At the policy level, the burden rests heavily with the DOD. If civil-military integration is not a visible and sustained management priority, almost on a par with the formulation of the nation's military posture, it simply will not occur. It must be the task of the leaders of the Department of Defense to reallocate and redirect resources, organizations, programs and policies towards this objective and to monitor progress continuously.

On the legislative side, the Congress must be not only supportive but proactive in removing the current barriers. For both the Congress and the DOD, giving speeches will not do it. Leadership, high priority and, most important, actions are required. The proposed integration strategy merits such attention because without it, the DOD will not be able to afford a viable military posture. Thank you.

[The prepared statement of Dr. Gansler follows:]

Prepared Statement by Jacques S. Gansler [1]

A FUTURE VISION OF THE DEFENSE INDUSTRIAL BASE

With the spectacular success of "Desert Storm" now largely behind us, Congress and the DOD must once again confront two major concerns: (1) how to reduce the costs of defense equipment and (2) how to maintain a viable defense industrial base that keeps costs to a minimum but also ensures a surge of production in any future emergency. With the likelihood of reduced defense budgets these goals will be difficult, if not impossible, to achieve under the current weapons' acquisition system; in fact, these objectives are often in conflict. However, an alternative approach to traditional defense acquisition practices exists, one that has the potential to achieve both objectives simultaneously.

Several distinguished task forces and government commissions on weapons' acquisition have concluded that the solution to this dilemma lies in far greater use of "civil/military integration". Under this approach, the Department of Defense—wherever it is appropriate—would rely on commercial products, processes, and buying practices. Such integration would allow many industries to employ the same technologies, personnel, administrative procedures, research, and production facilities for both commercial and military customers. The benefits would be twofold: *a far larger industrial base* available—when required—for defense production surge, but not dependent on the DOD for economic survival; and *significantly greater economies of scale and scope*—with the accompanying lower costs and higher quality—for all relevant defense products.

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[1] Dr. Gansler is Senior Vice President of TASC (since 1977). He is a former Deputy Assistant Secretary of Defense, a former electronics industry executive, and the author of *Affording Defense* (MIT Press, 1989) and *The Defense Industry* (MIT Press, 1980). Since 1984, he has also been a Visiting Scholar at the Kennedy School of Government, Harvard University.

Such integration was not possible in the past, since defense technology has usually been more advanced in performance and designed for more severe environments than normally experienced in the commercial sector. Moreover, commercial production generally required high volumes to achieve efficiency. Today, however, ruggedized commercial product technologies and flexible manufacturing process technologies have advanced to the point where such civil/military integration is both possible and desirable.

Under this alternative approach, the government would maintain only a very few, defense-unique sectors in the economy for technologies that are specific to defense, such as nuclear weapons. In these limited areas, the government must assure that the nation maintains, or at least has secure access to, some minimum core of engineering and production capability in each critical sector. As the sole buyer, it would be responsible for monitoring each sector's competitiveness, responsiveness, extent of foreign dependence, and rate of innovation. Additionally, the government would monitor the relative private and public sector mix. (With the shrinking defense budget there is growing concern about the increasing share of work going into the public—and pseudo-public—sector, i.e., to government labs, depots, arsenals, Federally Funded Research and Development Centers, etc.)

For most of its defense equipment needs, however, the government would work with the commercial sector for research, development, production, and support of its requirements, and/or for the direct acquisition of commercial materials, components, and equipment. In this future world, national assets—in technology, facilities, and manpower—would work together to enhance both U.S. security and economic competitiveness, ending today's inefficient and artificial division of productive resources according to end user.

Essentially, this vision encompasses—wherever applicable—three forms of civil/military integration: (1) dual use R&D (to common requirements), (2) plant integration (of engineering, production, and support), and (3) buying of common, ruggedized equipment, often at the subsystem and component levels—all made possible by greater reliance on commercial buying practices and commercial specifications and standards.

Such a strategy would require profound changes in the regulations and laws that govern DOD procurement and cost accounting as well as in the design approaches, specifications, and other characteristics that make up the traditional "unique defense acquisition culture." Nevertheless, *this strategy provides the best hope for addressing the problems that plague the defense industrial base; promises significant cost savings to the DOD at a time of budgetary crisis; ensures adequate surge capabilities to meet emergency military requirements; and at the same time strengthens the science and technology base in the United States.*

The achievement of this vision will be difficult and will take many years, but the time to begin is now. Without such a dramatic change, the U.S. defense industrial base will continue to devolve into a small, highly specialized, highly subsidized, inefficient sector that may soon be incapable of meeting the Nation's fundamental security requirements: namely, adequate quantities of affordable equipment; access to—and rapid fielding of—cutting-edge technologies; and the ability to expand selected production significantly when crisis conditions warrant.

The problem is that today the DOD cannot easily reach beyond its captive defense industrial base. DOD's "business as usual" virtually forces a separation of the private sector into two discrete economies: defense and non-defense.

To address this problem, we established a senior committee of government and industry leaders (see attachment 1) and performed a set of detailed industry case studies. We found that, in most companies, defense products are designed, developed, produced, and supported in isolated plants or independent divisions. Many companies either maintain separate research facilities for defense and commercial work or simply refuse to accept DOD research contracts. Similarly, most firms create separate engineering and production facilities for military work—a process that duplicates billions of dollars in capital and labor investments in the commercial sector.

This segregation of commercial and military work is also reflected in Federal research laboratories. Few of the DOD laboratories attempt or desire to exploit the growing synergies between military and commercial technologies. For example, the Department of Energy nuclear weapon laboratories are reluctant to give priority attention to joint laboratory-industry R&D projects on critical technologies despite strong industry support for collaborative programs.

This division of U.S. high-technology activities into defense and non-defense sectors has perverse consequences for the DOD:

— The low volume of defense orders means higher unit costs and therefore still fewer systems procured.

— A diminished production base limits the capability for production surge and is increasingly reliant on foreign sources for many critical supplies.

— The lack of access to commercial industry often means restricted access to state-of-the-art product and process technologies, which are increasingly being developed by the commercial sector.

The fragmentation of the U.S. high-technology sector also has an unfavorable impact on national economic strength. DOD is the largest single federal purchaser of advanced R&D. To the extent that its investments cannot generate dividends for the commercial sector, 70 percent of the total Federal investment in R&D supports only 6 percent of the GNP—an especially important point in light of the extensive overlap between the DOD defense critical technologies and the Department of Commerce emerging technologies, a further demonstration of the substantial interdependence among national security and economic competitiveness. Such separation clearly places the United States at a comparative disadvantage, compared to Japan and Western Europe. When the DOD component is subtracted from the overall R&D investment equation, the United States is being increasingly outspent by its major economic competitors.

Moreover, segregation of the military from the commercial sector artificially splits the national pool of human talent. Nearly one-third of all U.S. scientists and engineers are employed in military work; but, even within the same company, scientists and engineers in the commercial and military divisions rarely, if at all, communicate. Since human contact has been found to be the primary vehicle for technology transfer and, indeed, innovation, without links between the commercial and defense sectors, the pace of innovation in each is slowed—and both the Nation's security and its economic competitiveness suffer.

The traditional argument for this segregation is that defense technologies are unique. Either no commercial market exists for the product or the military's requirements far exceed anything the commercial sector can produce. And, of course, there is clearly little commercial demand for some defense-unique systems: an MX missile or an M-1 tank, for example. At the same time, the materials, components, and subsystems that make up those systems often have commercial counterparts that are (1) less costly, (2) equal to and, in some cases, more advanced than their defense with the broad movement toward an integration model (wherever applicable). Thus, we urge the government to implement more fully the provisions of the Stevenson-Wydler Technology Innovation Act of 1980 and the Federal Technology Transfer Acts of 1986 and 1989, which mandate greater efforts to transfer technology from the public to the private sector. In addition, we propose that Congress enact legislation to make cooperative industry-laboratory R&D ventures in critical technologies an explicit mission of the Federal and national laboratories. The increased opportunities for such collaboration, given the considerable overlap between technologies critical to both defense and competitiveness,should be exploited.

Attachment 1

COMMITTEE MEMBERSHIP

CO-CHAIRS

Senator Jeff Bingaman, Senate Armed Services Committee
Jacques Gansler, Senior Vice President, TASC
Robert Kupperman, Senior Advisor, CSIS

STEERING COMMITTEE MEMBERS

D. Babione, VP, Boeing Defense & Space Group
J. Beckett, formerly of Hewlett-Packard
C. Berkman, Chairman, Synektron Corporation
J. Bradshaw, Motorola, Inc.
L. Branscomb, Harvard University

J. R. Burnett, Ex. VP, Space & Defense, TRW
P. Carlson, VP, Honeywell,Inc.
T. Cooper, VP, General Electric
R. Costello, Hudson Institute
D. Dempsey, Akin, Gump, Strauss, Hauer & Feld
J. Duffey, Chancellor, University of Massachusetts
J. Foster, Jr., Chairman, Defense Science Board
S. Hecker, Director, Los Alamos Nat. Lab.
R. Helms, II, Research Triangle Institute
R. Hermann, VP, United Technologies
J. Jasinowski, President, National Assoc. of Manufacturers
D. Kerr, President, EG&C
Senator P. Leahy, Senate Appropriations Comm.
J. Lederberg, President, The Rockefeller University
H. Mark, Chancellor, University of Texas System
Representative N. Mavroules, House Armed Services Committee
Representative D. McCurdy, House Armed Services Committee
E. Meyer, Dean, Duquesne University
L. Reddy, President, Nat. Coal. for Adv. Manufacturing
G. Saunders, Dir. of Standardization, DOD
J. Schwartz, Prof. Math. & Comp. Sci. Courant Inst.
J. Sponyoe, VP, Gen. Man., Fed. Sect. Div., IBM
D. Trent, former CEO, Rollins
S. Turkish, Chief Scientist, Hughes
C. Vollmer, VP, General Dynamics
R. Williams, GM. Mil. Div., INTEL
G. Yonas, Director, Lab. Dev., Sandia

Attachment 2

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Findings:

— Accounting Requirements and Audits

Unique government accounting requirements—cost and pricing data, certifications, and audits—typically compel companies to establish a separate bookkeeping system to track the costs of defense contracts. Originally, these requirements were instituted to ensure that the government paid a fair price for the unique products it procured. Today, although the products may no longer be unique to Federal procurement (and the prices are established by competitive market forces), the accounting rules result in a higher priced item, even when a less expensive commercial counterpart is available. The cost of attempting (and failing) to achieve perfect accountability can be measured not only in higher dollar costs but also in how willing commercial firms are to do business with the government. Few companies want to alter their management controls and financial systems radically to comply with government requirements. As a result, many commercial firms simply avoid performing defense business, and others set up totally separate (higher cost) operations.

— Military Specifications and Standards

Historically, DOD has relied on detailed specifications and standards to ensure high reliability and performance of whatever product it was seeking to procure. These defined not only what was required but precisely how to build and test that product. Today, dramatic improvements in commercial technologies are yielding products that rival or exceed military requirements. Yet, if the commercial product or process does not exactly mirror DOD specifications or standards—even if functionally equivalent—it often cannot be sold to DOD. Moreover, because specifications are locked in at the time of the contract award (unless DOD decides to change them), any product or process improvements generated in the commercial sector cannot be incorporated into the DOD procurement without risking the charge of product substitution. Ironically, rather than establishing performance targets, the military specifications and standards limit DOD's access to the most advanced technologies, and, again, require separate facilities to satisfy often obsolete product or process specifications and standards.

— Technical Data Rights

DOD considers obtaining rights to technical data essential to operating, repairing, and maintaining its equipment and limiting potential price gouging by sole producers who may control the market and hence the product price. At the same time, DOD's emphasis on obtaining unlimited rights in technical data, including the right to distribute proprietary information to competitors, has created a major barrier to commercial and military integration. Under current regulations, a company could well lose its proprietary rights. This makes firms extremely reluctant to incorporate commercial technologies into DOD contracts. The emphasis on the government's limited rights also discourages companies from exploiting the commercial opportunities of defense supported technologies. Experience has shown that technologies that are potentially available to all companies will be exploited by none.

— Unique Contract Requirements

To do business with DOD, companies must comply with hundreds of unique federal contractual clauses that affect decisions on suppliers and sources, employment practices, and much more. Public funds are involved, so controls are clearly required. But the significant inefficiencies and high costs of administration are exorbitant compared to the commercial practices defined by the Uniform Commercial Code. The criminal sanctions that apply in the event of reporting error also make commercial companies reluctant to endanger their corporate reputation over rules that are unrelated to product quality or production efficiency. This vast and complex array of rules poses an entry barrier for small commercial businesses, which cannot afford the necessary administrative and legal help. Larger commercial companies, which tend to consider whether the added expense of administering government contracts is worth the fort, are increasingly deciding it is not. For both types of firms, the unique requirements of doing business with the government mandate a separate administrative structure for government contracts, effectively inhibiting synergies in R&D or production.

Recommendations:

— Accounting Requirements

The thrust of the recommendations is to broaden the exemption from cost and pricing data for all commercial products or products procured in competitive bidding. We also propose (1) exemptions from unique accounting regulations for those corporate operations whose primary business is in the commercial marketplace and (2) upgrading training in market research and price analysis for all DOD contracting officers. The objective here is twofold:

— to limit the applicability of DOD's unique accounting requirements to the defense-unique products for which they were intended (i.e., those products for which competitive market practices are not possible) or to those suppliers for whom they were intended (i.e., contractors whose primary business is defense) and

— to allow more commercial firms to offer products to DOD without incurring undue financial and administrative burdens on their primary business.

— Specifications and Standards

We urge DOD to create internal incentives, directives, and measures of successful implementation in each buying command that will move away from defense-unique process or product requirements. These changes include:

— reversing the bias in the Federal Acquisition Regulations (FARs) that favor purchases to military specifications and standards (MILSPEC);

— providing information and funding for procurement specialists to explore non-MILSPEC alternatives;

— upgrading training in commercial procurement, function and performance specification writing, and market research;

— incentives to prime contractors to identify cost-saving alternatives to MILSPEC procurement;

— creation of a pilot program within DOD to identify commercial substitutes at the materials, components, and subsystems levels—an analysis not performed today in the acquisition process;

— recognition that for commercial parts, specifications, and standards to be widely used, they must be designed into the systems in the R&D phase; and

— Finally, the congressional mandate for greater efficiency in procurement (the Competition in Contracting Act) requires clarification to permit truly effective competition within the framework of its intent. This should help to eliminate a great deal of overspecification, which perversely reduces competition and raises prices.

— *Technical Data Rights:*

The government must create a better balance between industry's proprietary rights and DOD's data requirements. The intent here is to constrain the government's demands for unlimited rights in data and software. These demands discourage companies from both incorporating commercial technologies into defense contracts and exploiting commercial opportunities arising from defense investments. We have proposed expanding the use of a modified form of government purpose license rights (GPLR) that would provide for unlimited access to technical data only if such access were needed for reprocurement and if DOD could justify that other procurement procedures were inadequate to meet its needs.

— *Unique Contract Requirements:*

The objective of the recommendations is to exempt commercial products and/or commercial suppliers from government-unique contractual obligations that are inconsistent with the Uniform Commercial Code that governs the majority of transactions in the private sector.

— *Federal Laboratory System:*

Finally, we recommend that even as these laboratories are reduced in size (corresponding to cutbacks in defense), they should also be shifted in their focus in a way consistent equivalents, and (3) capable of satisfying similar, or even more severe, environmental conditions. Additionally, the production (process) technologies utilized are also often identical—thus allowing factory-level integration, even when the final products themselves are dissimilar.

Defense technologies are unique largely because of the way the government procures them. Most companies do not segregate their defense business because their commercial lines cannot satisfy DOD's rigorous requirements but because meeting the procurement regulations would seriously jeopardize commercial efficiency and profitability.

We identified four areas of regulation or legislation as the dominant factors that drive a wedge between commercial and military business. In priority order, these are: accounting requirements and audits, military specifications and standards, technical data rights, and unique contract requirements.

In our report (released today) each of these four areas are analyzed in considerable detail—in terms of both the "barriers to integration" and the detailed changes required in order to remove these barriers. The objective is to create incentives for "world class" U.S. corporations to integrate their civil and military operations and to seek business with the government. The "findings" and "recommendations" of the report are summarized in attachment 2. While we believe these specific recommendations would clearly move the weapons' acquisition process in the desired direction, the critical need is for some concrete, significant action. Others, such as the Office of Federal Procurement Policy, have offered a slightly different (but very complementary) set of recommendations. Once a commitment to action is made and responsibilities assigned, each of the various alternatives can be evaluated (perhaps some even tried experimentally) and the process can move forward.

I should also note that while our study focused specifically on the defense sector, the constraints identified extend beyond defense procurement, contributing to inefficiencies in all government contracting. In addition, while concentrating on four principal barriers to civil-military integration (because they occurred most frequently in the case studies), it is recognized that, as these are removed, other barriers (of lesser significance, but important nonetheless) must also be addressed. These include logistics and support issues, export controls and trade constraints, and security barriers.

In summary, the defense acquisition system is required to meet many worthy goals: fairness to all bidders; elimination of contractor fraud, attainment of socioeconomic benefits from defense spending, and cost efficiency. The problem is that these goals often tend to be incompatible. At times, the emphasis is on fairness; while at other times, the goal is efficiency. As a result, the procurement system veers erratically between competing objectives without fully realizing any of them. A choice must be made.

The strategy proposed here emphasizes efficiency, innovation, and surge responsiveness. Essentially, it is proposed to transform the DOD into a "world-class" buyer—a buyer able to compete with other world-class buyers, for goods of high quality and low cost, from a domestic industrial base in which commercial band military production is, wherever applicable, fully integrated.

It is believed that, as this integration vision is realized, the increased availability and dual-use utility of a large share of the $38 billion of DOD R&D investments, and a similarly large share of the over $100 billion of DOD procurement and capital equipment investments, will help to stimulate U.S. domestic industry to be far more competitive—and, thus, to help reverse the growing trend toward a loss of U.S. international technological competitiveness and the corresponding increase in "foreign dependence" for the DOD.

To achieve this integration strategy requires, first, a total commitment to change by both the Congress and the DOD; and, second, a specific legislative and regulatory agenda for implementation.

At the policy level, the burden rests heavily with the DOD. If civil-military integration is 'not a visible and sustained management priority—almost on a par with the formulation of the Nation's military posture—it simply will not occur. It must be the task of the Deputy Secretary of Defense, the Under Secretary of Defense for Acquisition, and the Service Secretaries to reallocate and redirect resources, organizations, programs, and policies toward this objective and to monitor progress continuously. On the legislative level, the Congress must be not only supportive, but proactive in removing the current barriers. For both the Congress and the DOD, giving speeches will not do it; leadership, high priority, and—most important—actions are required. *The proposed integration strategy merits such attention, because without it the DOD will not be able to afford a viable military posture.*

Given this vision for the future, and a sustained commitment to regulatory and legislative reform, incremental changes are possible. The sum of those incremental changes will—over a few years time—result in the achievement of the vision, and, thus, in a strengthening of the Nation's ability to meet the security and competitiveness challenges of the 21st century.

Senator BINGAMAN. Thank you very much. I will begin by asking a few questions and then defer to Senator Coats and Senator Smith for any questions they may have.

It seems we have two subjects being discussed here. Mr. Schwartz, your comments are well taken and point out the difficulties that are faced by U.S. defense industry. Many of which are difficulties that the Department of Defense and the procurement system have imposed upon the industry.

As Dr. Gansler points out, not only are there difficulties, but I think, in expanding that set of difficulties, he is pointing out the difficulty of operating in both the commercial and the military sectors and the straightjacket that we put industry into.

Let me first just address the general question of how much this Congress or this government should try to involve itself. I know this is a difficult question and it's one that falls on the philosophical shoals very early on. Mr. Schwartz, you talked about how we can't afford to let the random process, which will occur as some companies go out of business and others stay in business, dictate who will, in fact, survive in our defense sector. You try to make a distinction and say we can't get into the business of picking winners and losers. Yet, we have to concern ourselves with maintaining a defense sector that is domestic and that can meet our needs. It seems we have an irreconcilable set of goals there, to an extent.

We are being presented with proposals by Department of Defense to shut down production lines in a variety of weapon systems. If we follow through on all of those recommendations we will, in fact, be picking winners and losers. We will, in fact, be reducing the size of our defense industrial production base very considerably, to the point where we have one contractor able to produce tactical aircraft by the middle of the decade.

Is that something that we can allow to occur in a random process? What is your thought as to how much pre-planning needs to go into that before we just shut down production lines because the need has been met?

Mr. **Schwartz**. Well, Mr. Chairman, I assume and I would hope that the decisions on which programs are going to survive have to do with considerations of the national defense, the viability of the individual programs and how they integrate into the whole force-structure plan of the Defense Department, and not picking companies one against the other.

The problem that I pointed out is that the system under which we are now working does not provide an adequate profit or return within the defense industrial base, so that companies will not want to invest their resources into the defense business. The random process by which management chooses whether to stay in the defense business or not is being dictated and imposed upon them because the defense area is no longer profitable. And, therefore, they are leaving in droves not because they do not have the capability to do the job well in defense, but because they're not providing their stockholders enough return.

It seems to me that we have to restore financial viability to the industry so that companies can be rewarded for good performance. I hope that the Defense Department, in shrinking the force-structure, will continue to cut out whole programs because that's the economic and proper way to proceed. But for those programs that do survive, I would hope there is going to be enough profitability so that competition in the industry can proceed in a vital and healthy manner.

Senator **Bingaman**. We put a provision in last year's authorization bill which authorized the award of a negotiated contract without discussions with offerors. Have you seen any effect of that, or do you have any opinion as to any benefit that might be derived from that?

Mr. **Schwartz**. I have only heard about but have not seen, on a contractual basis, the effect of those things in the industry. We still complain that issues like the elimination of best and final offers, the BAFOs, which are so destructive to the process from an industry point of view, have been banned by Department of Defense senior management but are still being imposed at the contract level. Another example is the elimination of the fixed-price development contracts, which are considered to be destructive.

We still find elements at the practical contractual level of a residue of these practices. They are still being imposed upon industry in a different form and a different shape but, nevertheless, the same kind of thing.

All of these efforts, Mr. Chairman, will be helpful to the industry, but they are taking an inordinately long period of time to seep down through the system to the contractor's level.

Senator **Bingaman**. Dr. Gansler, let me ask you a related question. Ever since I have been involved with this subcommittee when Senator Quayle, now Vice President Quayle, was then the chairman of the subcommittee, we have been trying to pass legislation urging more use of commercial products, urging that mil specs be brought into line with commercial requirements, and basically trying to reach some of these same results that you have set forth in this report. It doesn't seem that real progress has been made.

What can we do, or what needs to happen to actually break the logjam and get attention to the problem? It seems you have a vision in your report concerning the importance of more cross-over and integration wherever possible. But, when we get down to the details, it just seems terribly difficult to get this web of procedures and regulations revised so that any of that can happen.

Dr. GANSLER. It is very clearly a major cultural change. It is not something that you can just put out a memo saying, "Change from military-unique to integrated." It does involve all of the process from the accounting standards, from procurement practices, from the mil specs, from the legal considerations and from a lot of the legislation. So the only way that it will happen is with some clear, strong priority given to that and leadership continuously applied to it.

It has been recommended before; it has even been legislated before. And every so often, small changes are made. And it's not as though all of the people in the DOD are fighting it. There are people who are very much in favor of trying to do it. There are many more people who are resisting it simply because it is not the way they have always done business. It is a threat to their institutions, to the basic structure of the system.

And so my opinion would be that—and somewhat, Senator, it goes to the answer to the same question that you just asked Bernie. Are these really two different questions or are they very much related? I think they are very much related. The issue of how do we get lower cost equipment and have a viable defense industrial base, I think for the Department of Defense to address that question requires them to agree upon a vision, whether it's the one that is argued for in my testimony or some other vision, but at least state it and say if, in fact, it is going to be an isolated, unique defense industrial base, then what is the minimum level that we have to be able to sustain? What are the actions that we have to take in order to be able to maintain that, both engineering and production?

If it is just going to be that, in the defense-unique areas, and all the rest is going to be integrated because the arguments that I made may argue that that's an advantage, then someone has to say, "That is what we are going to do." And not only say it, but then weekly check up on what has been done and set milestones and try to achieve them in a measured success toward it.

What we hear now instead is, from the Congress and from the DOD, daily speeches that say, "Civil-military integration is good for you. Buy more commercial." And then the next day, passing a law against it or issuing a new regulation that prohibits it. And so there's an inconsistency. And you can't make a cultural change with that kind of constant oscillation.

There is a system that exists. It's the defense-unique one. If you're going to change it to one that is different, it has to take a major change in the system, and it won't happen just with the speech-making.

Senator BINGAMAN. Senator Coats?

Senator COATS. Thank you, Mr. Chairman. I apologize for being a little late and ask that my opening statement be included in the record.

Senator BINGAMAN. It will be included.

[The prepared statement of Senator Coats follows:]

PREPARED STATEMENT BY SENATOR DAN COATS

Mr. Chairman, I commend you for putting this hearing together on a series of issues bearing on the critical question of whether our industrial base can effectively support our Armed Forces. In the aftermath of Operation Desert Storm and as we approach a period of shifting international commitments and reductions in defense spending, we need a greater understanding of the impact of our decisions on the vitality of this sector of our economy.

The traditional categories of defense and commercial industries seem to be blending together as such technologies as electronic sensing and information processing become the underpinnings of our ability to project and apply military power. The research conducted in the commercial sector is essential for the fielding of many of our most critical technologies. As the Defense Department grows increasingly dependent on the component and products, such as computers, developed for the commercial marketplace, this subcommittee and the Department of Defense must broaden the focus of its oversight.

In the past, the Senate has initiated legislation establishing a more centralized management structure for industrial base policies. We have even mandated a more integrated process for managing information about those U.S. industries supporting defense. We must now ensure that the managers in DOD begin to use these tools to develop and implement the policies and programs to ensure that our dependency or reliance on foreign suppliers does not put at risk our ability to use our military in support of national security objectives.

The witnesses before us today bring a set of unique but essential perspectives. I look forward to engaging in a fruitful dialogue with all of them as we explore the complex, interrelated questions concerning the health of the industrial base supporting our Nation's defense.

Senator COATS. I, also, Mr. Chairman, want to thank you for placing on the panel two distinguished presenters with opposite points of view. One of my great frustrations and complaints about the system here is that we usually decide on a point of view and then invite the people to reinforce that, and we never really get out on the table the real fundamental issue that we're trying to deal with. And here we have two people on the same panel that are presenting alternative ways of achieving an end that I think we all want to reach, and I commend you for putting two people like this together on the panel to present us with the options.

In that regard, Mr. Schwartz, I guess I would like—I know you reflected in your opening statement that you did not think it was possible to achieve this integration. I wonder if you would reflect a little bit in more detail about Dr. Gansler's approach, this vision that we're talking about, and whether you think it's possible, or expand on the barriers to achieving that.

Mr. SCHWARTZ. Yes, Senator Coats. I might point out that I don't think Jacques Gansler's vision and my approach to the overall long-term view of the Defense Department acquisition structure are that different. I'm not sure we disagree.

What I am very much concerned about is that there is going to be a cost of this transition, and that the transition may take a lot of time. And I'm concerned that the burden will be put upon industry at a time when it can ill afford, because of recent performance, to bear that burden.

I hear rhetoric that integration is the way out of the problem. I don't know what the problem is in that regard. I don't think that integration is the way out of the problem. I think that the problem today, the near-term problem, is that we have an industry that is unhealthy because it is not profitable and has been made to be unprofitable by some very onerous circumstances. Those are correctable, in my view. If remedied, the short-term situation can help restore the industry to the kind of viability that would allow it to make investments into the kind of vision that Jacques Gansler is talking about. And I don't think we would disagree about that.

My concern is that there is a cultural problem. If, for example, defense companies that are totally involved with defense and not experienced in commercial merchandising and distribution, if we are obliged to compete against commercial organizations that have long experience and know how concerning distribution and merchandise in non-military areas with dual-source products, I think that defense companies are bound to fail. There are many things there that are impediments to defense companies.

The overhead structures that are imposed upon us by the government are not applicable to commercial activity. The separation of manufacturing facilities is not there because of some need to align. There are security problems and there are administrative problems that require some degree of separation between the two. The mil spec requirements, the standards requirements in the military area are an anathema to the commercial area. The numbers of units that are produced by military contractors are significantly smaller than those that are done on the commercial side.

Now, you might be able to have co-manufacturing facilities on the component parts, but in terms of testing and finishing, there is very definitely a different attitude and different requirements between the two end objectives. So, what I'm suggesting is, it's more than just culture. It does start from accounting, oversight, security, and mil spec standards that are much more severe in the military than in the commercial sector.

I think there are areas that we can coordinate. There should be an allowance by military contractors to use a commercial product. It is better than ours in many areas and we should be able to do that. But until the incentives are put into place, and until the government, the DOD, is able to say, "We will not pass these burdens of transition onto the industry," I sense that the burden of commercialization will be too much for industry management to take on.

Senator COATS. So you envision almost a two-step process. You share Dr. Gansler's vision of where we ultimately want to get to, but what you're saying is that you don't believe, in the present climate in the defense industry, it's possible to lay down that vision, as Dr. Gansler suggested, make a commitment to it and make the transition. You have to restore some health to the current system and then, through an incentive process at least in the short term, begin to move toward that ultimate goal. Is that a correct summary?

Mr. SCHWARTZ. Senator Coats, I think industry is skeptical that you will not place the cart before the horse, that you will put into place a new buzz word and a new philosophy that will put a heavy burden on the back of an industry that now has a transition problem of its own.

Long term, I think we would endorse and support a well thought-out, well-planned and well-incented and paid for program, because the industry will benefit from that in the end. But, in the mean-time, there will be few survivors if we think that dual-use technology is the answer to the industry's problem.

Senator COATS. And, Dr. Gansler, I would like you to comment on that, also. But if we follow Mr. Schwartz's advice and approach, in one sense it goes against what you said, and that is that a decision has to be made. If we're ever going to get there, we have to make the decision to get there and put it in place and begin to make the changes; otherwise, we're going to be—6 years from now, Senator Bingaman will be saying, you know, "When Senator Coats used to be here we . . ."——

Senator BINGAMAN. Now he's working for Loral or whatever. [Laughter.]

Senator COATS. "When Senator Coats used to be here, I remember we were talking about getting to this particular point and all we seem to do is talk about it, and now we're 6 years further down the line."

Dr. GANSLER. I can respond. I totally agree with Mr. Schwartz that we're not really talking about different solutions. We're talking about how we go about doing it and what we emphasize in the time period. I personally think it will take ten years to achieve this vision. It is not something that our government, certainly, or American people in general, are used to thinking about in horizons of that sort. But a cultural change of the sort we're talking about is going to take that time period.

During that time period, what you need to do is to have a healthy, innovative, responsive industrial base that gradually phases over from one that is almost completely unique to one that is largely integrated but still has some defense-unique pieces left in it.

Now, if you look back ten years from today, what we find is that we were, in the post-Vietnam period, going through a contraction of our defense industrial base. In the 1980's, we increased the amount of regulation so dramatically and all of the things that Mr. Schwartz just went through in terms of cost accounting standards, in terms of the procurement regulations and even in terms of data rights and things like that, that actually firms were forced to separate their operations during the eighties.

And if we now say what's going to happen in the nineties, what I'm arguing for is to say, "Where do we want to be in the year 2000," and then each of the individual actions that are taken between now and then, some of which will be to, in fact, maintain a viable, responsive, healthy defense industrial base, hopefully domestically, while we're making this transition. Some firms will remain defense-unique. But the overwhelming majority even of those will be buying their components and, in some cases, integrating their factories where it makes sense, where you can do it. Maybe you can use the same equipment to do, say, electronic radios for the Defense Department and also for the commercial world. And maybe you can't. If you can, then do so.

There are more and more examples that can be shown of where it has been practical to do it, but it is always by taking exception. Even in classified areas. The National Security Agency built a secure phone with commercial components in commercial facilities, but they had to take exception to almost everything. Now, it should be the opposite. The exception should be when it has to be defense-unique.

The practices today, from the federal acquisition regulations on through to the legislation, all start off by making the assumption that defense has to be unique. And I'm just simply arguing that, over this transition period, make a firm commitment to saying no, it's going to be the opposite direction. Defense isn't going to be always different, more expensive and more difficult to do business with.

Mr. SCHWARTZ. May I add one thing to my prior comments? I am truly concerned about the viability of the industry if, in fact, in integration, the definition of that means that we have a defense technology base without a defense production base. I am concerned about the viability of the industry and its capability under those circumstances.

Unless it's well thought out, I think the danger would be that, with integration, the commercial parts of the process having to do with manufacture and production will—because of the quantities and economic rewards involved—will totally dominate the defense production capability. And if that happens, I think we will lose something of vital concern to America's security.

Senator COATS. I have more questions but my time has expired. I'll get them on the second round.

Senator BINGAMAN. Senator Smith?

Senator SMITH. Thank you, Mr. Chairman. Mr. Schwartz, on page 22 of your testimony, your language is so graphic I guess you could say, "strong message to follow." Just to repeat quickly for emphasis, you say, "It's tough to intelligently manage a defense company while each year programs to which we have dedicated millions of dollars and countless people are slipped to the right, stretched out, put on hold, cut back, defunded, rescoped, descoped, canceled, reinstated, dead one day and back again the next."

Yet, in spite of all that, collectively, you all did a whale of a job, and have done a whale of a job. Why is it different now? I know the answer but I want to hear you say it. Why is it different now than it was then when you were so successful in spite of all of these things?

Mr. SCHWARTZ. That's a complex question, and timeframes are important.

About 10 years ago, the defense industry was doing very well. In the United States, there was an opening of the floodgates of resources that were poured into the defense industry beyond its ability to really manage them well. We did a lot of things fairly well—some better than others—and a lot of things badly because we were stretched to our capacity.

Ten years ago, when defense budgets were moving up very, very rapidly, everybody was doing well in the business because there were plenty of resources, and gearing up was the important thing. And perhaps some over-capacity occurred within the industry. And then, very rapidly, we were on a downhill trend. Over the last 6 years, we have not only had a non-growth budget but it has been a declining budget. And under those circumstances, intelligent management became more and more difficult.

But some other things occurred. The Defense Department attitudes toward procurement changed very dramatically against the industry. Some of this was justified as I say, because we were slow on compliance and we were slow in terms of total quality management. In reaction to that, perhaps the Defense Department's pendulum swung too far. Procurement procedures began to be onerous and it became impossible for defense contractors, even good ones, to continue to make money under very legitimate circumstances.

Senator **Smith**. Excuse me for interrupting. Is it fair to say that probably your successes in large part caused some of your problems in the sense that you were kind of on a roll there?

Mr. **Schwartz**. I think it invited an attitude toward defense contractors that we were thieves, that we were scoundrels and that we were raping the government. And the fact is, I would say, that the character of the defense industry in terms of integrity and non-integrity is not different from the rest of the fabric of American society.

But they treated us as if we were all thieves, and the reaction swung very far against anybody trying to make consistent profits within the industry.

Senator **Smith**. Later on in your testimony you use the statement, "R&D not translated into production is pure science lacking the vitality of application." I think you're right. And again, until we have the opportunity to see many of these systems in action, as we did in the Persian Gulf, I think perhaps in the minds of many people in the public it was science at that point. It had not been applied. We didn't know whether they were going to work in war.

I think that both of you, but specifically in your case, Mr. Schwartz, I think you have very accurately reflected what I perceive to be problems, and I hope that some in this Congress will listen because I am very concerned.

There was a committee meeting the other day and there was a chart presented where in most if not all of the major weapon systems that we deal with, the maximum number of sources was three, minimum one, and in some cases declining from one to zero, three to two, three to one. This is alarming. And I would hope that, in your case, Dr. Gansler, that some of the long-term solutions that you suggest, we can implement in the short term.

And I think another area, if we do have another round of questions, that I might like to get to is some of the concerns that we have of losing, at the subcontractor level, to foreign competition a lot of very critical supplies, which, in fact, could be detrimental to our national security.

So, if we do have another round, I would like to move into that. I compliment you both on your testimony very much.

Senator **Bingaman**. Dr. Gansler, let me ask you just to take a particular component which is a very vital one for virtually all the weapon systems we field today, and that's computer chips, microprocessors, DRAM's, the various array of integrated circuits that are required to operate, all the weaponry and smart munitions and other things that we are using these days. Is that an area where there is a significant opportunity for greater integration of commercial versus defense?

It would seem to me that the advances that have occurred in the commercial sector must have significantly outstripped what our needs are in the defense sector at this point, at least in most of these weapon systems.

Dr. GANSLER. Yes, Senator. In fact, that was the specific example that the 1986 Defense Science Board studied, the 1989 Defense Science Board studied and others have looked at. It also is important because I would guess over the next ten years, about 50 percent of defense procurement dollars will be spent on electronics. We will be upgrading most of our weapon systems with new electronics. Bernie hopes that will happen, I know. But I do believe that is going to be the case.

Now, the question is what kind of electronics. When you buy a car today, hard-mounted to the engine block of that car is a chip, which is basically a semiconductor computer, a small chip. If you look at the requirements for that, in terms of comparing them to the military systems, the temperature specifications are more severe. In other words, the extremes of high and low temperature for that chip that has to be mounted in a commercial application, and made in high volume, the temperature environments are more severe. The vibration, shock, humidity and all the others meet military specifications.

Now, what's important about that is that chip is more than an order of magnitude cheaper because it's produced in such high volume, and it is more than an order of magnitude more reliable because it is produced in such high volume and they have perfected the production process. And it is actually a couple of years ahead in performance, in terms of state-of-the-art performance.

Now you say, "Well, that's crazy. Then why don't we buy them?" Well, it turns out that, in our specification for the semiconductor chip, we have one word which says there is a "preference" for mil spec parts, and if you want to use commercial you must justify it. In 1986, the Defense Science Board recommended removing that word "preference." In 1991, it is still there. It is the strong resistance to change that is prohibiting——

Senator BINGAMAN. That is in the regulation, not in the statute; is that right?

Dr. GANSLER. It is actually in the specification, right, which is a regulation—I mean, it is written by the Department of Defense in that case. It is not required by law.

But if you start to then say, "Well, let's change the specification," then you start to get into the cost accounting. And the suppliers of these commercial chips feel that the prices are established through commercial pricing and they shouldn't have to then be subject to the audit, and they shouldn't have to be subject to the requirements that the government gets the best deal, which is one of the requirements. Even if the government is buying six and someone else is buying six million, the government wants to get the best price. Things of that sort are all throughout the regulations and legislation, in many cases. Some of it will be legislative, Senator, that would have to change.

But it is an obvious case to probe. It has been probed. People have now spent quite a bit of time trying to write a common specification for semiconductors. The semiconductor associations have, in many cases, favored it.

In many cases, it comes down to the fact that legislation is written around fairness as contrasted to efficiency, and there are some conflicts there. In the case of the semiconductor, the small firms have objected to a requirement for statistical quality control. If I am flying in an airplane, I would like that my chips had received statistical quality control, and so I would allow that as a requirement even though it may not be considered fair to some people.

There is a lot involved in the answer to your question but it is not technology. Those chips should be used and they are not being used today.

Mr. SCHWARTZ. And I might add that industry is not resistant to these suggestions. Industry is totally on board in favor of relaxing standards to utilize commercial product.

Senator BINGAMAN. Let me change the subject somewhat and ask, Mr. Schwartz, for your comments about all the ways that we change signals in government, and we certainly do.

Taking an example, Secretary of Defense has announced he wants to cancel the A-12. Could you give your views as to the circumstances that could have been avoided in the situation, where companies have made major investments and DOD decides to cancel the project? Was that a DOD problem, an industry problem, or a combination? What are your thoughts?

Mr. SCHWARTZ. I would not want to alter the Secretary's ability to cancel a program if he no longer sees the need for the equipment or sees that the performance and the cost do not meet their standards. I don't want to speak to the A-12 issue particularly, but I think the Secretary of Defense must have the ability to choose those weapon systems that meet his requirements.

The problem flows down the demand by the DOD of industry to put up front investments in R&D and early production investment without the ability, then, to recoup the investment because of the aborting of a particular program. The burden, therefore, shifts away from the Defense Department and onto industry.

The ATF is a more interesting example. There, the case involves development costs in the hundreds of millions of dollars, perhaps billions of dollars. of the two teams that were competing against one another. I don't know why it is necessary for the Defense Department to request of industry that kind investment up front with no opportunity to recoup its investment. I think that's the part that we are concerned about.

Senator BINGAMAN. Senator Coats.

Senator COATS. Dr. Gansler, I was surprised to hear you say that the commercial specifications often matched or exceeded military specifications, because I have been operating under the general rule of thumb that most of our military procurement was more complicated, cost more because the specifications were more demanding. Every defense plant I have ever visited has indicated that the specifications they are following, the tolerances, the durability, the fact that they have to meet specifications for extreme cold, extreme heat, extreme weather conditions, climate conditions and so forth were always much more stringent than any kind of commercial specifications.

And I am just wondering if you could expand on that. You mentioned the chip, and that may be the case, and maybe the equipment is getting sophisticated to the point where that can be integrated. I really don't know the answer, but I was just surprised to hear you say that.

Dr. GANSLER. I think the main difference, Senator, is what took place in the 1980's in terms of the technology change that really took place—in other words, your statement of prior to the 1980's I believe was a true statement. Defense not only asked for more extreme environmental conditions but, also, higher performance. And so it was always argued, "Well, of course, we pay more and we know we're paying more but we're getting something better."

The fact that, as the modern information era exploded, basically things changed. People are now putting chips on engine blocks in cars and using electronics everywhere. Essentially this explosion resulted in having to meet severe environments because it has to go on the desert and it has to go up in the North Pole in a car, and it has to still continue to work. Now, it doesn't meet radiation hardening. So there are some cases where you might have to have a radiation hardening requirement, for which then you have a defense-unique element associated with the part.

But, for the overwhelming majority of these modern electronic systems now,—I mean, literally, in Desert Storm we were using commercial GPS receivers working out there because they could be achieved in volume rapidly.

I think the primary complaint that I hear now from people is not that the specifications are tougher, it is that they are more rigid. And what commercial companies are doing now is continuously improving their process so they can make better, lower cost, more reliable items. The defense requirements, which when written were the state-of-the-art and were resulting in state-of-the-art performance and environment and so forth, are not flexible enough to be able to change as rapidly as the industrial ones are.

And so, today, we end up now with industrial processes that if you go to an electronics plant,—say you go to Motorola and down the street they have a defense plant—they are using more advanced processing, lower cost, higher quality in their commercial operation than in their defense plant down the street; and they are doing the process down the street in the defense plant because that is what the requirement says to do.

Senator COATS. Mr. Schwartz, you are nodding your head; I guess you agree with that.

Mr. SCHWARTZ. I have heard the management of Motorola complain about this specifically. It is not just that the specifications are different; they are different. It is not just that the performance is different. With commercial products, there are many items that can meet the performance requirements but not meet the mil spec standard; and, therefore, we are prohibited from using those products. This also involves a cultural change. It is nothing more than someone getting in there and allowing the management of the defense operation the flexibility to use one part versus another part.

Senator COATS. To prove that they can, in fact, use the commercial product to meet the standards.

Dr. GANSLER. Satisfying a functional requirement, a performance requirement as contrasted to—did I solder it the way they told me to? The more important question is: Does it work? And that's the test you would want to have the commercial item subjected to, as contrasted to: Does it meet my detailed specification?

Mr. SCHWARTZ. Why would a manager of a defense plant use the flexibility he determines will work in the end product if, in fact, he can be brought up for investigation by the GAO for not following the processes that are outlined in the specs? There are disincentives, therefore, to be flexible.

Dr. GANSLER. That is a very important point. It is not just the mil specs that are the disincentives here. In fact, in our case studies we didn't find that was the highest priority item at all. What we found were things like the cost accounting standards, the auditing, the threat of going to jail, if you will. These are driving away world class companies from defense today, not because they can't satisfy the functional requirements, but because they just feel it is not in their business interest to continue to supply to defense.

So you will end up with people, like Mr. Schwartz said, who aren't the winners, who are the only ones willing to put up with all that. And that is not what I think the Nation needs.

Senator COATS. Mr. Schwartz, as a defense contractor, do you agree with Dr. Gansler's statement that if we are going to make reductions,—and we are—they ought to be in whole programs rather than in partial programs, stretch-outs and that type of thing?

Mr. SCHWARTZ. If we are going to make reductions?

Senator COATS. Yes.

Mr. SCHWARTZ. I think it is a determination of the DOD and I think they are on the right track. That is to say, cutting every program by 10 percent for budgetary reasons is exactly the wrong way to go. Cutting whole programs and getting rid of the whole infrastructure of those programs, the whole cost involved under the programs, is a much more economical way to proceed. But I am hopeful that such decisions are made for national security reasons rather than budgetary reasons.

Senator COATS. But that could result in a further—I guess what you are saying is that it's better to face the music now, rather than let the whole industry slide, identify—because some of those decisions may result in further weakening if not eliminating a component of the defense industrial base.

You know, the argument has been, let's keep this production line going, or let's keep this particular weapon system going because we want to keep that defense industry alive, not knowing what we are going to need from them in the future.

Mr. SCHWARTZ. I don't think the industry would request that it be subsidized. That is to say, if it is not putting out a particular product that meets a particular program requirement, the industry generally would not ask the government to pay for it just to stay alive.

Now, the circumstances of closing a whole plant because the program is going to be terminated can have a very serious economic impact on the community and on the industry. But in the main, at the end, the industry would be well served and be healthy if, in fact, it was allowed to produce and to be rewarded for good production, rather than subsidized for unnecessary production.

Senator COATS. Thank you. My time has expired.

Senator BINGAMAN. Senator Smith.

Senator SMITH. Mr. Schwartz, let me be the devil's advocate for a moment. Let me go back to your example of the ATF, which essentially has consisted of two consortia vying for the same contract. Why wouldn't the contractors agree to such an agreement? From the government's point of view, my position would be, if I offered you the opportunity to form a consortium and do the research and expend the monies to win the contract, I assume that a good business decision would be that I can afford to lose it or I wouldn't take the risk. That would be a reasonable assumption, would it not?

Mr. SCHWARTZ. Not necessarily when you only have one customer and the program's opportunities are declining because of the budget emphasis. So it may be that if you are in the manufacture of airplanes or airplane engines or radar warning receivers on those airplanes and you only have one opportunity, you may take risks that are inordinate and, in hindsight, may be very damaging.

But the fact is we only have one customer. We can't go across the street and sell it to somebody else. And when that customer says, "We are going to have a competition for a plane that is going to be around for 15 or 20 years," there are strong incentives to step up to the line. The problem is with the collateral issues of unfair competition being imposed upon industry—best and final offers on a continuing basis, technical leveling, not being paid for high engineering content, and having to compete with companies that do not have high engineering content on the same price-only basis.

Senator SMITH. I agree with you. However, I think where I do disagree is I think that using the ATF example, I would have stepped up to the plate, both of them, and said to the government, "We can't do that. If you want an ATF, then you're going to have to do better than that. You're going to have to give us some more assurances."

In my opinion, the industry holds more cards on this, better cards than you might expect. But I don't want to argue it. I understand your point. It is a shame. I have seen both of the videos on those aircraft and it is a shame that there has to be a loser in that.

I just want to touch on one other issue, Mr. Chairman. In The Washington Post, March 25, there was an article by staff writer Stuart Auerbach, "U.S. Relied on Foreign-made Parts for Weapons." An unbelievable array of dependence was outlined in that article. I won't go into it all, but I would like to just cite a couple of them, and in so doing, maybe, Dr. Gansler, you could respond.

Do we have or do you think we could produce some cost-effective method to track these lower-tier suppliers of key components to see whether or not we could identify and assess foreign dependence? Is there perhaps some computer database or some way that we could do this?

Just to give a couple of examples, the guidance system of the Sparrow, for example, contains circuits made from Japan. "When American manufacturers ran short of critical parts for the video display terminals needed to analyze real time intelligence data from reconnaissance plans in the Gulf, the government went to the

Japanese Embassy. On nearly 30 occasions, the Bush administration needed help from foreign governments to get delivery of critical parts for the war effort."

This has all been pretty well documented. Given the constraints of free enterprise, what can we do about that? Even though these are "friendly" companies, it is still a grave concern to me that we, for the first time as far as I know in American history, we placed American troops in harm's way without really being totally dependent upon America for the weapons that we needed to defend them and for them to use offensively as well.

Dr. **Gansler**. The answer to your specific question, there is not a system in existence today. There has been discussion about developing such a system. It is not an extensively difficult thing to do. It is certainly well within the state-of-the-art of data processing and so forth, and one could do that, and I know the Department of Defense has talked about doing that.

The more important question is what would you do with the data if you had it. And, as you properly point out, there have been studies done now for the last—at least that I'm familiar with—for the last 6 or 8 years that have shown the growing percent of foreign dependency, both in the products and in the processes that we use. The question is: Do you want to do anything about it? Is that a concern? Does it make you more vulnerable? Does it make you less assured of access?

And I think you have come down to the fact that you want to go back to the critical industries and critical technologies issues. In some cases, it is very much of concern to me. Particularly, I am concerned not because I buy a part from offshore that a ship will sink coming from Tokyo to San Francisco, but, if the part manufacturing goes offshore, then the engineering follows it. And when we go to design our next generation system we don't have any engineering in, say, electronics in the United States. I think that's a national security issue. It also is a major economic issue, as far as I'm concerned and I think one that we should have visibility into, which is what you're suggesting, Senator, but then have some plan to do something about it in areas that are critical.

Now, I think we have the leverage to do something about it. With the $38 billion of defense R&D and the over $100 billion of defense procurement, we certainly have enough leverage. We have demonstrated that, in areas where we want to stimulate the R&D, stimulate the industry, stimulate the buying, because you do need the production as well as the R&D, that we can do something about it.

I would personally argue that if those were more dual-use products, these components and so forth that we are buying from offshore, if they were being bought onshore and dual-used, we would then have the volume that might justify production in the United States, and the stimulation from defense would, I think, help that.

I think that, in the long run, we are going to clearly have parts in all of our systems that are bought offshore. If, in fact, you could just as easily buy them onshore but you are buying them offshore because they're a little better or a little cheaper or whatever reason, that doesn't concern me so much if I have the option, in other words. If I have the engineering and production.

So the first question isn't give me a list of how many I bought offshore, but am I dependent on one source in one country? And is that a critical technology that I couldn't easily duplicate or substitute for. Now, if I get that visibility in those areas that are critical to defense,—and most of those are critical to the economy as well because of this overlapping of technologies—I would do something about those areas. I would have a technology strategy in the United States to address those questions, to become a domestic producer in the next five years and leap frog the competition in those areas. We don't have such a strategy today.

Senator BINGAMAN. Thank you very much. I plan to go on to the next panel. Did you have any follow-up questions for this panel, Senator Smith? If so, please go ahead at this time. Otherwise, we will let them get on about their work.

Thank you both very much. I think it has been very useful testimony and we appreciate your being here.

Our second panel consists of Mr. Paul Math and Mr. Nic Torelli. Mr. Math is the Director for Research, Development, Acquisition and Procurement Issues for the National Security and International Affairs Division of GAO. GAO recently submitted a study done at my request entitled, "Industrial Base Significance of DOD's Foreign Dependence," and Mr. Math will testify this morning on the results of that study, as well as possible approaches to addressing the questions raised by foreign dependence. Many of those questions are ones we have just been discussing.

Mr. Nic Torelli is the Deputy Assistant Secretary of Defense for Production Resources. He is responsible for policy development and implementation and oversight of weapon system production resources, including industrial engineering and quality and manufacturing modernization in the industrial base. He will testify this morning on the department's efforts to better integrate commercial products into defense systems.

Let me go ahead and ask Mr. Math to start, and then we will move to Mr. Torelli.

STATEMENT OF PAUL F. MATH, DIRECTOR, RESEARCH, DEVELOPMENT, ACQUISITION AND PROCUREMENT ISSUES, NATIONAL SECURITY AND INTERNATIONAL AFFAIRS DIVISION, U.S. GENERAL ACCOUNTING OFFICE

Mr. MATH. Thank you, Mr. Chairman. I have a prepared statement. I would like to summarize it at this time.

Senator BINGAMAN. That's fine. We will include the entire statement in the record.

Mr. MATH. We appreciate this opportunity to appear before your subcommittee today to discuss the Department of Defense dependence on foreign sources for critical components of its weapon systems.

In a global economy, foreign sources of supply, manufacturing and technology are an economic reality and abound in both the commercial and defense sectors. Many experts agree that trends regarding increased use of foreign sources should be closely monitored. The principal national security concern regarding foreign sourcing for critical components and weapon systems relates to whether a dependency exists and constitutes a risk or vulnerability to the United States. In other words, not all dependencies pose such a threat to national security.

My testimony is based on our report issued on January 10, 1991. Briefly stated, we reported that DOD does not know the impact or significance of its foreign dependency problems; DOD's awareness of dependencies is limited; previously identified dependencies still exist; and DOD's efforts to develop adequate information on dependencies have been slow in coming and inadequate.

Because DOD has only limited information and does not have a reliable information system on foreign sources and dependencies at the lower tiers of the supplier base, the overall extent of foreign sourcing and foreign dependency is unknown. Moreover, no criteria have been established for determining what the levels of foreign dependency tolerance should be for various items, and what actions DOD could or should take to reduce the associated risks. As a result, DOD has not put itself in a position to know the seriousness or significance of its overall foreign dependency problem.

Demonstrating that a dependency exists and that it results in a risk to national security requires the systematic collection of data as well as an analysis of various factors such as: (1) reliability of the foreign supply source; (2) substitutability between unreliably supplied foreign goods and alternative goods, including the length of time needed before alternatives become available; (3) the importance to the defense mission of the final products affected; and, (4) the likelihood of a national security contingency in which the availability of the item might be critical.

In recent years, a number of studies have surfaced increasing concerns about dependencies on foreign sources for critical components for our weapon systems. For example, a study by the Joint Logistics Commanders reviewed 13 DOD weapon systems and found dependencies on foreign sources in eight of them, with severe problems in six.

Recently, we examined whether foreign dependencies for selected items previously identified in the Joint Logistics Commanders study still existed for the M-1 Abrams tank and the F/A-18 Hornet aircraft, two weapons used in the Persian Gulf war. We determined that these items continued to be foreign dependent.

However, the problems go well beyond these two specific weapon systems. We found that, overall, DOD officials have little awareness of the extent of foreign sourcing or dependency in their weapon systems, particularly beyond the prime contractors and their immediate subcontractors. DOD program officials are not required and take no special action to maintain visibility into foreign sourcing or dependency.

DOD has ongoing efforts to, (1) improve its information on the U.S. defense industrial base and, (2) revise the DOD Acquisition Directive and procedures to include early consideration of foreign sourcing and dependency issues. However, both these efforts have been slow in coming and have significant limitations.

For example, DOD's efforts to systematically collect and analyze information on foreign sourcing do not address the issues of foreign sources used at the subcontractor level. DOD has acknowledged that its defense industrial network, DINET, a prototype defense industrial database, has many limitations. DOD has a proposal to develop a full-scale system to address industrial base issues, but there are no DOD-approved plans for its implementation.

In addition, according to DOD officials, revisions to DOD's acquisition and industrial preparedness guidance and procedures are intended to require program managers to analyze, from the early stages of the acquisition process, the capability of the U.S. industrial base to meet production requirements for weapon systems. The revisions explicitly include consideration of foreign sourcing and foreign dependency. However, defense industrial base experts we spoke with expressed concerns about whether program managers, without assistance from the officials responsible for industrial preparedness planning, would effectively assess the capabilities of the U.S. defense industrial base including the risks inherent in foreign source to produce their weapon systems.

As we previously reported, we believe that an improved approach to defense industrial base data collection and coordination, especially at the subcontractor levels of production, is necessary for DOD to properly plan and be in a position to take action regarding the industrial base.

The 1986 JLC study recommended, among other things, that DOD develop a management information system to obtain visibility on foreign dependencies for weapon system components throughout the lower production tiers. Participants in the JLC report and DOD officials told us that this report received limited attention except from defense groups specifically concerned with mobilization or industrial preparedness, and its contents and recommendations, therefore, were not fully considered or addressed.

In April 1990, the Logistics Management Institute issued a report stating that the majority of recent studies and reports on the defense industrial base have not been comprehensively evaluated, nor have their recommendations been prioritized. The report also states that sound recommendations have received only passing attention or have been ignored completely by DOD. The Institute recommended that the Secretary of Defense make a senior-level group responsible for evaluating and prioritizing such recommendations, establishing schedules for review and implementation of selected initiatives, and holding specific individuals or organizations accountable for meeting these schedules. DOD officials told us that the Institute's report has not yet been seriously considered; therefore, DOD has not assigned responsibilities to any group or individual.

We support these LMI recommendations, and we reaffirm them in our recent report.

We also recommended that, after consulting with other agencies and private sector experts and considering existing studies regarding critical technologies, critical and strategic industries and foreign dependencies, the Secretary of Defense should: (1) determine the key issues and policy questions for which information is needed; (2) develop a plan for a viable management information system to provide visibility on foreign dependencies for weapon systems components throughout the lower production tiers; and, (3) submit within a reasonable time a program proposal to the Congress for effectively addressing the key issues and policy questions.

That concludes my prepared statement, Mr. Chairman.

[The prepared statement of Mr. Math follows:]

Prepared Statement of Paul F. Math, Director, Research, Development, Acquisition, and Procurement Issues, National Security and International Affairs Division, United States General Accounting Office

Mr. Chairman and members of the subcommittee:

We appreciate this opportunity to appear before the subcommittee today to discuss the Department of Defense's (DOD) dependence on foreign sources for critical components of its weapon systems. As you know, the term foreign source refers to sources of supply, manufacturer, or technology located outside the United States or Canada. A foreign dependency exists if there is no immediately available alternative domestic source.

In a global economy, foreign sources of supply, manufacturing, and technology are an economic reality and abound in both the commercial and defense sectors. Use of foreign sources generates some benefits as well as some concerns. Many experts agree that trends regarding increased use of foreign sources should be closely monitored. The principal national security concern regarding foreign sourcing for critical components of weapon systems relates to whether a dependency exists and constitutes a risk, or vulnerability, to the United States. Not all dependencies pose such a threat to national security. However, such a risk or threat would exist if the United States were to become so dependent on a foreign source that its ability to produce critical weapon systems and/or secure the most advanced technology for the development of a future weapon system were to be compromised.

My testimony is based on our recent report, *Industrial Base: Significance of DOD's Foreign Dependence*, issued on January 10, 1991, (GAO/NSIAD-91-93). Briefly stated, we reported that DOD does not know the impact or significance of its foreign dependency problems; DOD's awareness of dependencies is limited; previously identified dependencies still exist; and DOD's efforts to develop adequate information on dependencies have been slow in coming and inadequate.

SIGNIFICANCE OF DOD'S FOREIGN DEPENDENCE

Because DOD has only limited information and does not have a reliable information system on foreign sources and dependencies at the lower tiers of the supplier base, the overall extent of foreign sourcing and foreign dependency is unknown. Moreover, no criteria have been established for determining what the levels of foreign dependency tolerance should be for various items and what actions DOD could or should take to reduce the associated risks. As a result, DOD has not put itself in a position to know the seriousness or significance of its overall foreign dependency problem.

Overseas sources of supply may provide economic and political advantages that include lower costs, better technology, better integration with our allies, and access to an industrial base much larger than our domestic base. However, there are potential disadvantages associated with foreign source procurement. These include dependencies on foreign sources that may be less reliable suppliers than domestic ones, particularly in times of crises. Another potential disadvantage is a lack of DOD access to advanced technology, developed in other countries, that may be important to the qualitative superiority of our weapons, a key element of our military strategy. Even if DOD does subsequently obtain such access, reduced capability to domestically produce technologically advanced products could result. A third potential disadvantage is reduced domestic production capabilities, when domestic manufacturers do not have sufficient demand to keep production lines open; in other words, U.S. businesses or industries shrink or fail.

Demonstrating that a dependency exists and that it results in a risk to national security requires the systematic collection of data as well as an analysis of various factors, such as (1) the reliability of the foreign supply source, (2) substitutability between unreliably supplied foreign goods and alternative goods, including the length of time needed before alternatives become available, (3) the importance to the defense mission of the final products affected, and (4) the likelihood of a national security contingency in which the availability of the item might be critical.

Several studies that we reviewed presented options to reduce the risks arising from DOD's dependence on foreign sources for materials and components of major weapon systems. Some of these options involve broad policy decisions relating to such things as tax incentives and anti-trust law revisions. Other options are more program-specific and include advance procurement and subsidization for the stockpiling of critical, foreign-sourced components and materials; creation and funding for domestic research and development and/or production capacity; funding government-owned facilities; substitution with domestically sourced items; component redesign to use domestically available items; domestic licensing of foreign design; and import restrictions. A final option is for DOD to establish its weapons requirements, to the extent possible, based on what is available in the U.S. commercial industrial and technological base.

DOD'S AWARENESS OF DEPENDENCIES IS LIMITED AND PREVIOUSLY IDENTIFIED DEPENDENCIES STILL EXIST

In recent years, a number of studies have surfaced increasing concerns about dependencies on foreign sources for critical components for our weapon systems. For example, a study by the Joint Logistics Commanders [1] reviewed 13 DOD weapon systems and found dependencies on foreign sources in 8 of them with severe problems in 6. According to the study, the dependencies identified could result in a total cutoff of the production of these items as early as 2 months into a war mobilization effort for a period lasting from 6 to 14 months.

Recently, we examined whether foreign dependencies for selected items, previously identified in the Joint Logistics Commanders' study, still existed for the M-1 Abrams tank and the F/A-18 Hornet aircraft, two weapons used in the Persian Gulf war. We determined that these items continue to be foreign dependent. Examples include the F/A-18 ejection seat and, for the M-1 tank, optics in the gunner's primary sight, and microcircuits in the computer that aims and fires the tank's main gun.

However, the problems go well beyond these two specific weapon systems. We found that, overall, DOD officials have little awareness of the extent of foreign sourcing or dependency in their weapon systems, particularly beyond the prime contractors and their immediate subcontractors. DOD program officials are not required, and take no special action, to maintain visibility into foreign sourcing/dependency.

In the cases where foreign sources were awarded the work under DOD contract or subcontracts for the Abrams tank and the F/A-18, it was usually because of availability, quality, and cost considerations. For those items in which cost was the primary consideration, contractors stated that even if DOD were willing to pay the higher prices of domestic suppliers, they would be unable to satisfy DOD's total requirements because of production capacity constraints.

DOD acquisition and industrial preparedness personnel associated with the Abrams tank and F/A-18 aircraft programs have no systematic method for identifying or collecting data on foreign sources or foreign items used in their respective weapon systems.

Production contractor officials for both of these systems were able to supply us with some information about foreign sourcing below their immediate subcontractors, but said this information is not kept systematically. One official said such lower tier information is largely dependent on the expertise and experience of the particular buyer.

Abrams tank and F/A-18 aircraft officials were not aware of any actions taken on any item for their respective weapon systems to specifically reduce production risk from exposure to foreign sourcing or dependency. In some instances, program officials and contracting officials took action on production problems associated with foreign-sourced items, but often they discovered that the item was foreign sourced only after its loss had threatened production schedules.

The two production contractors did not mitigate foreign dependency or vulnerability by maintaining "buffer stocks" or "rolling inventories." Personnel of one contractor told us that (1) independently maintaining such extra stocks makes little economic sense for their company and (2) if the government considered maintenance of such stocks important, the government would have to require and pay for them.

DOD'S EFFORTS TO ASSESS FOREIGN DEPENDENCIES

DOD has ongoing efforts to (1) improve its information on the U.S. defense industrial base and (2) revise the DOD acquisition directive and procedures to include early consideration of foreign sourcing and dependency issues. [2] However, both these efforts have been slow in coming and have significant limitations. The latter effort will have difficulty in succeeding because it relies on program managers who have higher priority concerns.

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[1] *A Study of the Effect of Foreign Dependency*, (Feb. 15, 1986).

[2] DOD Directive 5000.1, *Major and Non-Major Defense Acquisition Programs*, and DOD Instruction 5000.2, *Defense Acquisition Program Procedures*.

INFORMATION COLLECTION AND ANALYSIS

DOD efforts to systematically collect and analyze information on foreign sourcing do not address the issue of foreign sources used at the subcontractor level. DOD has acknowledged that its Defense Industrial Network (DINET), a "prototype" defense industrial data base, has many limitations. DOD has a proposal to develop a "full-scale system" to address industrial base issues, but there are no DOD-approved plans for its implementation.

DOD's efforts to systematically collect and analyze data on foreign sourcing and foreign dependency have been slow in developing and have not been adequately justified to receive the necessary support. DOD started the DINET project in 1985. At the beginning of fiscal year 1990, DOD expected the project to be completed in 1993. However, the project has never really left the prototype stage.

REVISED PROCEDURES

According to DOD officials, revisions to DOD's acquisition and industrial preparedness guidance and procedures are intended to require program managers to analyze, from the early stages of the acquisition process, the capability of the U.S. industrial base to meet production requirements for weapon systems. The revisions explicitly include consideration of foreign sourcing and foreign dependency. However, defense industrial base experts we spoke with expressed concerns about whether program managers, without assistance from the officials responsible for industrial preparedness planning, would effectively assess the capabilities of the U.S. defense industrial base, including the risks inherent in foreign sourcing, to produce their weapon systems. In this regard, program officials of the two systems we reviewed commented on the limited contact between industrial preparedness planners and procurement officials and the separation of the industrial preparedness planning and acquisition processes within DOD.

DOD ACTION IS NEEDED

As we have previously reported,[3] we believe that an improved approach to defense industrial base data collection and coordination, especially at the subcontractor levels of production, is necessary for DOD to properly plan to be in a position to take appropriate action regarding the industrial base. Such planning needs to take into account such factors as the economic, trade, and technology security implications of procuring items and components of major weapon systems from foreign sources.

The 1986 JLC study recommended, among other things, that DOD develop a management information system to obtain visibility on foreign dependencies for weapon system components throughout the lower production tiers. Participants in the JLC report and DOD officials told us that this report received limited attention, except from defense groups specifically concerned with mobilization or industrial preparedness, and its contents and recommendations therefore, were not fully considered or addressed.

In the context of DOD's handling of the JLC study recommendations, it is noteworthy that in April 1990 the Logistics Management Institute (LMI) issued a report, *Implementing Industrial Base Study Recommendation*, stating that the majority of the recent studies and reports on the defense industrial base have not been comprehensively evaluated, nor have their recommendations been prioritized The report also states that sound recommendations have received only passing attention or have been ignored completely by DOD. The Institute recommended that the Secretary of Defense make a senior-level group responsible for evaluating and prioritizing such recommendations, establishing schedules for review and implementation of selected initiatives, and holding specific individuals or organizations accountable for meeting the schedules. DOD officials told us that the Institute's report has not yet been seriously considered; therefore, DOD has not assigned responsibilities to any individual or group.

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[3] *Comments Relating to Reauthorization of the Defense Production Act*, (GAO/T-NSIAD-90-10, Mar. 1, 1990) and *Industrial Base: Adequacy of Information on the U.S. Defense Industrial Base*, (GAO/NSIAD-90-48, Nov. 15, 1989), discusses our evaluation of certain aspects of the Federal Government's data collection and coordination efforts among agencies that play an important role including the Department of Commerce and the Federal Emergency Management Agency.

We support these LMI recommendations. In our report, we recommended that the Secretary of Defense assign responsibility to an individual or group within the Office of the Secretary of Defense for identifying, reviewing, evaluating, prioritizing, and, when decisions have been made to take action, following up on timely implementation of the recommendations of major reports and studies on the defense industrial base to better enable DOD to take advantage of potentially valuable ideas.

We also recommended that after consulting with other agencies and private sector experts and considering existing studies regarding critical technologies, critical and strategic industries, and foreign dependencies, the Secretary of Defense should (1) determine the key issues and policy questions for which information is needed, (2) develop a plan for a viable management information system to provide visibility on foreign dependencies for weapon systems components throughout the lower production tiers, and (3) submit, within a reasonable time, a program proposal to Congress for effectively addressing the key issues and policy questions.

Mr. Chairman, this concludes my statement. I will be happy to respond to any additional questions you or the other members of the committee may have.

Senator BINGAMAN. Thank you very much. Before we go to any questions, let me call on Mr. Torelli to go ahead with his statement.

STATEMENT OF NICHOLAS TORELLI, DEPUTY ASSISTANT SECRETARY FOR PRODUCTION RESOURCES, U.S. DEPARTMENT OF DEFENSE

Mr. TORELLI. Thank you, Mr. Chairman. Sir, I have a formal statement for the record, if——

Senator BINGAMAN. We will include it in the record.

Mr. TORELLI. Thank you very much. I will synopsize the statement.

Buy for best value; consider supplier's past performance; accept commercial operation maintenance and safety data; use commercial logistics support; use commercial packaging; use commercial item descriptions where market acceptability allows. Those are words right out of the new DOD Instructions Policy Governing Defense Acquisition 5000.1 and Defense Acquisition Management Policy and Procedure 5000.2. They apply specifically to commercial items at this point. It will be expanded in the future.

The keys behind my testimony today, are commercial practices and best value, competitiveness, and the relationships of these subjects to the Defense Acquisition Board and the whole acquisition process.

First, commercial practices. In the summer of 1989, Mr. Atwood testified before the Congress and described to Congress the approach that DOD would pursue—commercial practices, that buying commercial was good. "Best value" was the way we were going to go in the future. Performance or function-based specifications instead of detailed military specifications were also the way to go. Taking advantage of commercial technology and moving things in the right direction was DOD's policy.

We have started along that track. Smarter use of the commercial marketplace is our initiative. We are expending significant effort training our people. We have created a two-day course where we go on-site to the buying commands in all of the services and the Defense Logistics Agency to talk about buying non-developmental items, buying commercial. There are two separate versions of the course, one for systems acquisition and one for items of supply acquisition. Systems acquisition more at a higher level, items of supply down in the commodity type.

But the key here is training. You don't turn this on overnight. As Dr. Gansler said earlier in testimony, he thinks it is a 10-year process. My goal, from a strategic side, is I think that strategy-wise we will need a significant amount of time.

My responsibilities inside the Department of Defense cover the computer-aided acquisition logistic support area, manufacturing technology—as we testified last week, specifications and standards, technical data, production readiness, industrial engineering and quality, evaluation of the production base and industrial preparedness planning. It feels very significant to me that a strategic plan across all those areas is something that the Department of Defense has made a commitment to by putting them into one area and focusing it the way they have.

In the areas of specifications and standards, we have heard a lot already this morning about that. The evolution into performance-based specifications instead of the detailed, designed-based military specifications, that you see a lot of nowadays, is going to take some time. We have, in fact, conducted a review over the past year or two, of specs and standards and looked at ways to go from military specifications to commercial item descriptions and non-government standards as much as possible. We have slated a reduction of about 10 percent. I see that as a beginning. There is more coming.

In the area of technical data rights, we are working with industry right now on a new rule for technical data rights to simplify a lot of the areas of concern from this morning.

Also, contract flowdown. It was mentioned earlier in discussion about the subcontractors, and what we do to impose unnecessary requirements on the subs. I spent the last 12 years in industry and understand the requirements on subcontractors very clearly, both as a production manager and as a program manager. The subcontractors don't need those kinds of extra requirements, and we are working toward training so that we can flow less down to the subcontractors. The key point, again, as I said, is competitiveness, and that leads me into the next area of concern.

As you reduce the amount of flowdown to subcontractors you, in fact, make them more competitive which makes the prime more competitive.

Foreign dependency versus foreign sourcing is an issue. We have a broad market environment. As Mr. Math specifically addressed a few minutes ago, U.S. companies are looking overseas, because they see some cost and some quality benefits in a lot of cases. There is global competition, a global market right now; these are facts of life. We gain technology overseas sometimes; we also gain coalition support. The negative side, obviously, is the potential for vulnerability.

As we see a change in the threat from the Soviet Bloc—Warsaw Pact—that adds one thing from my perspective: there may be a little bit more lead time added to potential mobilization situations.

On our data base, we have a defense industrial network that is a prototype system. As we see the data base evolving, there are more things that need to be added. We are, in fact, putting together a plan. The key is that the plan is integrated, so that we address issues at the whole acquisition process level instead of just addressing foreign dependencies.

As I said, foreign sourcing remains a concern. As we discussed last week, Mr. Chairman, there are significant instances of foreign sourcing for parts of our weapons systems. But, as we try to find the best, most cost-effective program for acquisition, we may, at times, go overseas to get it.

Now let me address some production issues. I have spent the most significant amount of my last four and a half months in DOD—which is my whole tenure here—working on Defense Acquisition Board (DAB) items. The DAB process is being streamlined. I see some very positive things to do in terms of an overall strategic plan. The critical industries report, the integration of the critical industries report with the critical technologies plan, looking at the national defense stockpile—those things come together into what I perceive as a DOD strategy for how we address the future.

The key part is the ability of the industrial base to support these programs. My production base experts are now involved in the DAB process. It is only recently that industrial engineers began working from the start of the acquisition process, with discussions with the production base people. Now, as I said, the organization is together within my purview, and those communication links are now happening.

Last year, we were tasked to deliver a report on three key prime contracts and their impact on the industrial base. Those were the Advanced Anti-Tank Weapon System-Medium (AAWS-M) anti-armor weapon system medium for the Army, a Mark 50 torpedo for the Navy, and the Short-Range Attack Missile-II (SRAM-II) missile for the Air Force. The requirement was to address key subcontractors, sole-sourced critical components, foreign-sourced critical components, strategic and critical materials, potential production constraints, and the contractor's ability to meet peacetime, surge, and mobilization requirements. That report is in staffing right now. It has passed my office and should be delivered to Congress very soon.

The key point here is that we are now looking at the industrial base as a matter of course for DAB programs. That is the goal. We understand that to maintain a good, sound industrial and technological base, we must be doing better planning at the front end. That is, in fact, in process.

Mr. Atwood, a few weeks ago, identified some issues that also came up this morning. In the 1980s, there was more defense money and sometimes contractors worked in areas that were not too productive—there was not as much discipline in the process as there is now and will continue to be. As we see cost overruns, we understand that there may be some management issues, some identification of cost, schedule, and performance issues that must be looked at in much more detail.

As we go through this process of Defense Acquisition Board streamlining and coming down to fewer contractors in a much more competitive environment, I feel that we will be playing a significant role in the strategic planning.

Thank you very much.

[The prepared statement of Mr. Torelli follows:]

PREPARED STATEMENT BY MR. NICHOLAS TORELLI, DEPUTY ASSISTANT SECRETARY OF DEFENSE (PRODUCTION RESOURCES)

FINANCIAL STRENGTH OF THE DEFENSE INDUSTRIAL BASE, INTEGRATION OF COMMERCIAL AND MILITARY TECHNOLOGIES, AND DEPARTMENT OF DEFENSE DEPENDENCY ON FOREIGN SOURCES FOR WEAPON SYSTEM PARTS AND COMPONENTS

Mr. Chairman and members of the subcommittee, I appreciate the opportunity to discuss with you the integration of commercial and military technologies and the strength of the defense industrial base.

A strong industrial base and the integration of commercial and military technologies are vitally important to the Department of Defense (DOD) and the overall health of the Nation. In these times of shrinking budgets and with the memories of the recent military operations still fresh in our minds, their importance is more obvious than ever. I feel strongly about my own responsibilities in achieving these goals as Deputy Assistant Secretary of Defense for Production Resources.

During the hearings held, in June of 1989, by the Senate Subcommittee on Oversight of Government Management on DOD use of commercial and nondevelopmental items, Deputy Secretary of Defense Atwood committed the Department to making more effective use of commercial items. Immediately following that hearing, we established an aggressive agenda aimed at breaking down barriers to buying commercial items. I would like to present some of the ongoing actions from that agenda to the committee today.

In our development and use of specifications and standards, we are purposefully moving away from military-unique requirements and toward standard commercial requirements, wherever it makes sense. This will not only allow the purchase of commercial items, it will encourage such purchases. We are also purposefully moving away from specifying design requirements in contracts and toward functional and performance requirements to allow flexibility in manufacturing and technology. We are accomplishing this change through training our acquisition corps, through revisions to our regulations, and through the use of nonregulatory guidance, such as handbooks.

We recently completed the development of a new training course on buying nondevelopmental items (NDI). The objective of the course is to better equip our acquisition personnel to good buying decisions and, when that decision is to use a commercial product, to carry it out effectively. In this "full spectrum" training, we move through the acquisition process from the genesis of the need to the delivery to the user, identifying potential impediments to buying commercial items and ways to avoid or overcome them. We have two versions of the course—one geared to "system acquisitions," where there is great potential for commercial use at the system, subsystem, component and part levels, and one geared to "items of supply," such as consumable and durable goods, an area in which we have made some progress and to plan to do even better. The importance of researching the commercial market and using performance based requirements is stressed in both versions of the course. We give special attention in the "items of supply" version to writing simplified item descriptions, to utilizing market acceptability requirements, and to developing strong lines of communication with users and suppliers to get feedback on the quality of the items bought. We began offering the courses at buying activities around the country in January of this year and will be holding at least 50 classes during the remainder of the year.

Our basic acquisition directives—"Policies Governing Defense Acquisition" (DODD 5000.1) and "Defense Acquisition Management Policies and Procedures" (DODD 5000.2) were recently revised to include specific direction on considering commercial alternatives at the beginning of each new procurement, as well as at the subsystem, component and part levels within a system procurement. In DODD 5000.2, we are directing that the acquisition strategy should be tailored to the extent feasible to employ commercial practices when purchasing commercial items. The following commercial practices are specifically spelled out in the new directives: buying for best value, considering suppliers' fast performance, accepting commercial operational, maintenance, and safety data, using commercial logistics support, and using commercial packaging and using commercial item descriptions in conjunction with a market acceptability requirement. Market acceptability provisions require that a product must have gained market acceptance in terms of volume of sales, length of time in the market, or other appropriate criteria. In support of the DODD 5000.2 directive, we have issued detailed guidance on the preparation of commercial item descriptions and the use of market acceptability. This guidance is aimed at ensuring that these descriptions will be simple, function or performance oriented, generally easy for industry to understand and use, and result in the purchase of quality products.

We have published a DOD handbook, entitled "Buying NDI." This manual specifically addresses the integration of commercial items into our procurement process. It is used in conjunction with the training course and as a stand-alone guide. We are also preparing another handbook specifically aimed at providing specification writers information on doing market research and incorporating the results of that research into an item description. We also plan to publish a compendium of commercial acquisition case studies this year, which will serve as a "lessons learned" document. Both of these publications will be incorporated into our training curriculum.

As part of the Defense Management Review (DMR), we did a complete review of all of our specifications and standards, some 35,000 documents. The review criteria included the currency and the necessity of these documents, as well as the appropriateness of maintaining a military specification or standard, as opposed to an industry standard or commercial item description. As a result of this review, we have begun the conversion of 3,500 of our military documents to industry standards or commercial descriptions, and 1,500 more will be canceled.

In the area of rights in technical data and software, the Department has been making progress toward development of a combined Federal Acquisition Regulation (FAR) Rule, which is equitable to both government and industry. These efforts have been under the chairmanship of the Director of Defense Procurement staff and have included inputs from various sources, including industry and government agencies. The final combined FAR Rule on rights in technical data will be an aggregate of beneficial recommendations taken from these inputs.

We are also working with industry to address their concerns regarding cost or pricing data requirements for sales of commercial products to the government. The recent legislative increase in the Truth in Negotiations Act (10 U.S.C. 2306A) threshold from $100,000 to $500,000 will encourage many commercial contractors who want to sell products to the Department of Defense.

In addition, we are continuing to review the regulations governing accounting requirements to identify those provisions which impede the acquisition of commercial products and recommend changes where possible. On September 6, 1990, we published a proposed rule in the Federal Register aimed at streamlining and simplifying current requirements for obtaining an exemption from the submission of cost or pricing data. The proposed rule eases exemption criteria by permitting contracting officers to grant an exemption for contracts of $1 million or less for cases which do not strictly meet the exemption criteria, such as items that are new to the market. In response to the proposed rule, over 266 public comments have been received from 49 sources. The public comments have been analyzed and policy issues are currently being addressed. We anticipate publishing an interim rule to give interested parties additional time to respond to the changes prior to publishing a final rule. We expect that our proposed changes will be a significant step in removing impediments to the purchase of commercial products.

To encourage suppliers to offer commercial items to DOD, new regulations will be published this month that simplify DOD's contracting procedures for commercial items. The new regulations eliminate DOD unique requirements in the following areas:

— Quality assurance
— Specifications and standards
— Packaging and marketing
— Technical data acquisition
— Licensing of computer software

The proposed change also reduces the number of contract clauses that we will use in contracting for commercial items and limits the clauses that may "flowdown" from prime contractor to subcontractor. This proposed rule will also be published as an interim rule, allowing additional public comments to be solicited.

These new regulations will remove many of the procedural impediments that discourage suppliers from offering commercial products to the Department of Defense. There are, however, a number of areas in the U.S. Code that apply to Department of Defense contracts but not to contracts in the private sector. The public comments received in response to the proposed rule suggest that these existing statutory requirements pose significant impediments to potential suppliers. Although we continue to make improvements to the regulations and procedures we use to buy commercial items, we cannot fully emulate commercial practices within the current statutory framework.

You have requested that I also address DOD dependency on foreign sources for weapon system parts and components today.

Foreign sourcing has become a fact of life for many defense contractors. It is a function of the fact that DOD's defense contractors operate in a broader market environment that has become increasingly international. On the positive side, the incorporation of global capabilities into the defense sector of our industrial base provides a number of benefits to DOD and to national security. Access to foreign production capabilities and technologies has enabled U.S. producers to achieve improvements in defense equipment in a cost-effective way. Foreign participation broadens the supplier base both in terms of production sources and technology. It provides the advantages of competition, higher quality and lower cost, that might otherwise be absent in highly specialized and narrow market niches limited to domestic sources. This, of course, is consistent with long standing public policy and congressional mandate requiring the marketplace and competition to dictate sourcing of DOD's purchases.

The negative side of this issue is the potential for foreign dependency, defined as the lack of adequate U.S. or Canadian sources for a particular component or material used in a weapon system. A distinction needs to be made between foreign sourcing and foreign dependency. Foreign sourcing is not a serious issue so long as a domestic manufacturing capability is available or can be readily established. In contrast, foreign dependency is a concern for DOD if it translates into a vulnerability, i.e., the potential that urgently needed defense production could effectively be shut down by the loss of foreign sources.

As the global economy has made a defense industrial and technological autarchy impractical if not impossible, the impact of foreign dependency on national security is cautiously tempered by a diminishing Soviet threat. With the reduction of the threat comes a plausibility of a longer warning, thus our previous concern about foreign dependency can be substantially softened. If the primary threat is perceived to be Third World conflicts such as Desert Shield/Storm in which the United States is operating in concert with international coalitions, the probability of interdiction or arbitrary cut off of foreign sources may not be high.

Notwithstanding this basic mitigation, foreign sourcing remains a concern of DOD, one that we have acted upon to assure visibility and management attention. In order to address production issues like foreign sourcing, the Department of Defense is placing greater emphasis on incorporating industrial base planning into the acquisition process for major acquisition programs. Responding to a congressional requirement, we recently completed a study on the ability of the industrial base to support the development and production of three weapon systems—the AAWS-M (anti-armor weapon system) missile, Mark 50 torpedo, and the SRAM II (short-range attack missile) missile. For each system we identified key subcontractors, sole sourced critical components, foreign sourced critical components, strategic and critical materials, potential production constraints and an overall assessment of the contractor's ability to meet peacetime, surge and mobilization requirements. A process for performing industrial base analyses on all new major acquisition programs is currently being institutionalized with industrial base factors considered at every acquisition milestone review. To help program offices meet this requirement, we're preparing to assure industrial base issues are addressed for all major system acquisitions.

In addition to increased emphasis on industrial base issues in the acquisition process, we have made a significant revision to our basic industry data collection process, which includes a specific focus on foreign sourcing of critical components. To make this information accessible and most useful to the DOD industrial planning community, we are developing specific enhancements to our data system. DOD is continuing to examine other ways to collect information on foreign sourcing. Our current DOD data system includes all DOD direct procurements over $25,000 from foreign sources. Efforts are underway to identify and obtain access to other databases containing foreign sourcing information at lower production tiers.

We believe the programs we are putting in place, particularly those requiring industrial base issues be addressed early and throughout the acquisition development program, are effective and prudent. I appreciate the opportunity to speak with you this morning. I will be happy to answer any questions.

Senator BINGAMAN. Thank you very much. We passed a statute a couple of years ago directing or requiring that DOD solicitations use performance functional descriptions rather than traditional mil specs. Are you saying that that has been implemented, or what is the status of that?

Mr. **Torelli**. I am saying it's starting, sir. As we flow this down and perform the training necessary to get to the buying commands, those types of procurements are, in fact, happening.

Senator **Bingaman**. I know you have training for contracting officers. But I am asking now about the solicitations that are going out, whether they are, in fact, using performance and functional descriptions rather than mil specs.

Mr. **Torelli**. The training that is going on is not just for contracting officers—it is for buying commands and their acquisition personnel, which really does cover the whole waterfront of what you are addressing, sir. We started that training in January of this year. We have 50 courses that will be performed by the end of this year, and that is expected to expand.

Senator **Bingaman**. How many people will be exposed to that training by June of this year?

Mr. **Torelli**. About 600 by the end of June, about 1,500 people by the end of the year within the buying community.

Senator **Bingaman**. Fifteen hundred out of how many?

Mr. **Torelli**. I don't have that number, Senator. I will get you that.

[The information follows:]

Acquisition Workforce

Most narrowly defined, the Acquisition workforce comprises only those who negotiate and administer contracts for major weapon systems. Broader definitions include activities occurring outside the contract process, such as documenting the need for a new weapon, testing systems under development, maintaining systems in the field, and disposing of outmoded, unneeded equipment. Service organizational structures generally group these functions together. A still more comprehensive perspective would encompass all those who procure the ordinary goods, such as office supplies and delivery vehicles, needed to support any large organization within DOD.

Three general methods are available for estimating the size of this workforce:

1. Surveying actual job activities;
2. Counting people in specified occupations; and
3. Counting entire organizations.

Experience has proven the first to be impractical; the second and third, used separately, inevitably miss some employees with significant procurement duties. A combination of occupational and organizational count, while perhaps marginally overstating the total workforce, is necessary to take into account all personnel involved in these procurement duties.

Applying this method against a "cradle to grave" concept of acquisition is consistent with the charter of the USD(A), which assigns authority for the "system whereby all equipment, facilities, and services are planned, designed, developed, acquired, maintained, and disposed of within the Department of Defense." This method encompasses 11 service commands and one Defense Agency, as well as those who work outside these organizations in 9 civilian occupations and 38 military officer specialties. It adds 4 commands to a list developed by the General Accounting Office (GAO) in an earlier study of defense acquisition. This method also adopts the same job categories used by the Packard Commission in estimating the size of the acquisition workforce. The following table represents the most recent personnel totals available:

ACQUISITION WORKFORCE

	Employment [1]	
	Civilian	Military
Acquisition Organizations		
1. Army Information Systems Command	18,817	1,701
2. Army Materiel Command [2]	105,592	2,773

ACQUISITION WORKFORCE—Continued

	Employment [1]	
	Civilian	Military
3. Office of Navy Research	5,029	114
4. Naval Facilities Engineering Command	19,650	730
5. Naval Air Systems Command [2]	43,903	1,128
6. Naval Supply Systems Command [2]	26,278	640
7. Naval Sea Systems Command [2]	110,181	1,424
8. Naval Space and Warfare Systems Command [2]	28,572	630
9. Air Force Logistics Command [2]	86,676	3,109
10. Air Force Systems Command [2]	28,366	10,407
11. Air Force Communications Command	6,921	4,088
12. Defense Logistics Agency [2]	53,134	[3] 795
Other Organizations		
Acquisitions Occupations [4]	18,645	
Acquisitions Specialities [4]		[3] 2,828
Total	551,764	30,367
Grand Total		582,131

[1] As of December 31, 1988. This does not include subsequent programmed reductions.
[2] Listed by General Accounting Office as "buying commands."
[3] Estimated.
[4] As identified by Packard Commission.

Senator BINGAMAN. My impression is that it's tens of thousands when you look at all the different services, is that right?

Mr. TORELLI. I don't want to guess, Senator. I am not sure.

Mr. TORELLI. Mr. Math, do you have any idea how many people there are in these positions, these contracting officers? Do you have any idea, Mr. Math?

Mr. MATH. I don't have it. It is in the tens of thousands, as you mentioned.

Senator BINGAMAN. You said you are trying to move ahead with the purchase of commercial products wherever possible, both in—I think you referred to them as items of supply, and also in systems or components of systems. Where is the greatest opportunity for cost savings to the government, and what can be done the most easily in those categories?

Mr. TORELLI. What can be done the most easily is probably items of supply. As we see an example that I was afforded yesterday, buying lubricating oil to put in automobiles. We have eliminated the military specification on buying lubricating oil for automobiles like what we use in terms of moving vehicles around in Washington, DC or whatever, moving people, so that we now buy a commercial lubricating oil right off the shelf. We saved 30 percent right off the top by doing that.

Senator BINGAMAN. You mean DOD has been paying 30 percent more for oil than the rest of us?

Mr. TORELLI. Not just DOD, sir. It is everybody that has any kind of a mil spec. If you are buying oil for a government automobile, you are probably buying from a mil spec.

Senator BINGAMAN. Yes, but that is DOD; right? There is not a mil spec that applies for GAO or GSA or anybody else in the government. It is just DOD; right? DOD is the one with the mil spec—

Mr. Torelli. I am not sure on that one, either, sir, and I will find that out. I have a feeling that we all buy the same thing.

Senator Bingaman. Your understanding is that, historically, we have paid 30 percent more for oil for DOD than the rest of the world was paying because we had a mil spec.

Mr. Torelli. It is at least for DOD. That's correct.

Senator Bingaman. At least for DOD. Maybe for the rest of the government, but you are just not sure. That does seem like something that needs fixing.

[The information follows:]

Automotive Lubricating Oil

The Defense Logistics Agency is the integrated materiel manager for automotive lubricating oil. In that capacity, they consolidate requirements for lubricating oil government-wide and purchase, on a regular basis, sufficient quantities to meet those requirements. The military specification for automotive lubricating oil was converted to a commercial purchase description and first used in contracts for oil in December 1990. As a result of this conversion, a savings of $500,000 is anticipated over the contracting period of 1 year. The total value of the contracts awarded in December is approximately $4.9 million. Factors contributing to the savings include changes to technical, packaging, marking, and quality assurance requirements.

Mr. Torelli. But those are the kinds of things that we go train for. It really does sound funny, but people don't understand that, in the days of creating systems, there were extra requirements or there were felt to be extra requirements. As Dr. Gansler described earlier also, we're seeing technology catch up with where mil specs were, in some cases, the commercial technology is superior.

Senator Bingaman. Let me ask just in a real nuts and bolts sense, how do you get these mil specs eliminated? Does it come up as someone says, "Hey, this doesn't make sense," or do you have a systematic task force, a group of experts whose job it is to meet every week and come forward with recommendations and eliminate these mil specs?

Mr. Torelli. There are several different vehicles. Yes, sir, we do have a task force. As a mil spec ages—I think it is a 5-year requirement—we review each military specification for adequacy and continued need. It is like a sunset provision—we review them at that point. We will be doing a standardization and data management conference in May where I am going to speak, and that is a vehicle to present to the entire community—that is industry and government—the possibilities of what can be done.

So it's exposure to the people out there going, "Hey, this isn't a good idea." Industry presents a lot of these back to us as feedback.

Senator Bingaman. Yes, but if I were an oil company I wouldn't call that one to your attention. I would just keep charging you an extra 30 percent.

So, if industry doesn't call it to your attention, and the time period or sunset provision on these things hasn't expired, do you have a group that you sit down and say, "Okay, your job for the next 90 days is to come up with a list of these mil specs that should to be eliminated"?

Mr. Torelli. The Defense Management Review set up a working group called Working Group 9. That is a task force that is still meeting, and this is almost 2 years now since this working group was formed. And that is the charter of that group, to go evaluate those mil specs.

Senator **Bingaman**. Working Group 9?

Mr. **Torelli**. Working Group 9, yes, sir, of the DMR.

Senator **Bingaman**. Could we get a report on the specs that they have identified?

Mr. **Torelli**. Sir, we have—I don't have the exact data here, but out of about 35,000 military specs and standards, the working group has recommended 3,500 for conversion to either commercial item descriptions or non-government standards and another 2,300 for cancellation. So, as I said, we are working on the issue.

Senator **Bingaman**. They have recommended that. It hasn't been adopted?

Mr. **Torelli**. It is going to happen. It will happen, sir. I don't have the exact data on when things have been canceled. They are in process right now.

Senator **Bingaman**. If you could get us a report on their recommendations and how many have actually been implemented. If they are making recommendations that are just sitting on someone's desk, we would like to know that.

Mr. **Torelli**. The ball is in my court, and I am not going to let it sit, personally, because I understand the competitiveness issue very well, having come out of industry for 12 years. So I will get you some information on that for the record, sir.

[The information follows:]

Working Group 9

Working Group 9 has not completed their work. To date, approximately 3,500 documents have been recommended and scheduled for conversion to either nongovernment standards or to simplified, commercial item descriptions. Another 2,300 documents have been recommended and scheduled for outright cancellation, without replacement. The recommendations are not just sitting in someone's in-box. The document preparers are moving ahead with cancellations and conversions as scheduled—as quickly as resources permit. Working Group 9 is currently doing some self examination to establish some degree of confidence that they have done a thorough job. When the "sanity check" has been completed, the final report including statistics and a description of planned actions to ensure lasting improvement to the process for preparing specifications, will be sent to the Under Secretary of Defense (Acquisition) for approval.

Senator **Bingaman**. We would appreciate that. Senator Smith.

Senator **Smith**. Thank you, Mr. Chairman. Mr. Torelli, I am not certain but I believe you were here last week when Mr. McMillan testified, Assistant Secretary McMillan, and I questioned him on his citing a difference between the terms "rely" and "depend" in terms of being reliant upon or dependent upon foreign contractors. He said there is a difference. Do you agree with that statement?

Mr. **Torelli**. Well, since it was me that passed the note to him, it is my mistake, and I will go on record to correct it. The words I was trying to say were "depend" and "source." So, I need to correct the record on that.

Senator **Smith**. If you look up the two words, rely says to depend upon, and depend says to rely upon.

Mr. **Torelli**. Well, I blew it and my boss took the hit, and I need to apologize for that, sir.

Senator SMITH. I appreciate that because—it is not something I want to dwell on, but I think it is interesting because in the same Washington Post article that I referred to earlier with the last witnesses, the headline says, "U.S. Relies on Foreign-made Parts for Weapons," and the term "dependence" is used four or five times in the gist of the article. So, apparently, the writer uses them interchangeably.

Mr. TORELLI. I would also use them interchangeably.

Senator SMITH. Okay.

I guess I moved a little bit into this testimony prior to you and it was really more your area than the previous witnesses. But it just seems to me that, as far as foreign suppliers are concerned, we either have to change existing business practices or change the way we do business with business, if you will, to make it more conducive for businesses to produce more of these products we are talking about. That would be in the interest of national security, to either stockpile parts, or a little of both.

It doesn't seem to me like we are doing either. Our business practices are driving business out of the country for a number of reasons, both commercial and military. I don't want to get into it all here; it's not the appropriate committee to do it, but—for tax reasons and others, labor, you name it, we are doing it. I don't think we are dealing with that issue at all.

Again, citing the same article, Commerce Under Secretary Kloske, who was in charge of making sure industry was mobilized to supply the fighting forces in the Gulf, said one area of U.S. vulnerability comes in the ~~U.S.~~ electronics industry. He cites the dependence or reliance, and he said that, "This requires greater stockpiling, especially of critical electronics components that only are available from foreign suppliers."

But former Commerce Under Secretary Lionel Olner, who was a member of the Defense Science Board, said its studies show Defense Department procurement officials "often have little idea what parts in the U.S. weapons came from overseas. Such parts often were small but critical components that were bought by the contractors and subcontractors," et cetera. Further, Olner said, "It would be too expensive to begin stockpiling all the foreign-made parts used in weapon systems."

That is a shocking statement when we have our Armed Forces dependent upon some of those materials, many of those materials. "Drawing on his Pentagon experience, Kloske added, 'The military generally opposes stockpiling parts and ammunition, preferring to use its money to buy weapon systems.' " Well, I might ask the rhetorical, "What good is a weapon system if it doesn't have any parts to make it work?"

I would like your response to some of these points, and I want to make one other point here if I can find it.

Well, I can't find the other point that I was looking for. But the bottom line is there seems to be no effort to stockpile, no effort to reform the bad practices in the relationship between government and industry that are causing the problem to begin with. What is your suggestion on how we ought to deal with this? Either one of you gentlemen feel free to answer.

Mr. **Math**. First of all, with regard to the sourcing, dependency and vulnerability, I would agree that it is expensive to stockpile every part that might be out there. Now, the services normally have inventories for 10, 30, 60 days for the items they stock depending on the war scenario. So, in normal inventory stockage, they would include, theoretically, the foreign-dependent or foreign-sourced items.

The issue at hand, we believe, is the need to get the information first and then consider the options that are available, whether it be stockpiling, whether it be deciding that you need another source in the United States, or whether, on a broader scale, you want to talk about tax benefits and policies or antitrust changes to get the capability for people to produce. Whatever options are available should be considered for use once you understand not only the extent of foreign sourcing, and then the dependency, but then also the cases of national security vulnerability.

You can have a source outside the United States, you can have a dependency outside the United States, but how vulnerable is the government to that dependency? If it comes from Great Britain, are we extremely vulnerable for a selected item?

So I think you have to do that analysis up front before you decide what are the most viable options. And it should be on a case-by-case basis rather than saying we're just going to stockpile all items that we think might be foreign sourced.

Senator **Smith**. I understand that and I would agree with that. One final point.

According to the Post article, "Foreign manufacturers often were reluctant to put the Pentagon purchase orders ahead of their regular customers"—whoever they were—"without prompting from their governments, according to officials here and the Commerce Department. But there was no case of a foreign manufacturer refusing to supply parts for political reasons."

Well, I would just leave you with this thought. Supposing the coalition had not come together and there had been some resistance on the part of many of these suppliers, Japan, France and others, to participate and, therefore, not provide the requested supplies. I think this is a red flag that we were perhaps somewhat lucky that it didn't turn out worse than it did, and I think it is something that deserves a good, long, hard, comprehensive look whether we stockpile or whether we don't; whether we change business practices or we don't; or whether we do a combination of both. Let's do something. I'm very concerned about this.

Mr. **Math**. We would agree, Senator. Again, the first thing is the information. But, also, we stated in the testimony that you need to develop criteria for vulnerability, and that is not available, either.

Senator **Bingaman**. Let me ask Mr. Math if you would comment on DINET. I think, Mr. Torelli, you mentioned it in your testimony as a prototype system. My recollection is that we had real trouble getting Department of Defense to even acknowledge that it existed a year ago, and they asked for no money for it. If there has ever been something that was a low priority in the Department of Defense, we found it when we found DINET.

Mr. Math, maybe you have had occasion to look at that in your studies.

Mr. MATH. I would agree it is a prototype. It hasn't, to our knowledge, gone beyond the prototype phase, and as we understand it, it has an extremely low priority. And currently, in its prototype stage, it is projected to have considerable limitations that are going to have to be ironed out in the future.

Senator BINGAMAN. It is supposed to be an office to collect information on foreign dependency or the extent of the purchases that we are making from foreign suppliers? Is that right?

Mr. MATH. It will include that, as we understand it. It is not solely for that purpose. In other words, it will include other industrial base pieces of information. But it also is designed to incorporate the sourcing information.

One of the problems was, as we understand it, that some of the information systems that were going to be used to provide input into this system were not very good systems to begin with. Some were voluntary, they were not all-inclusive, and they did not go all the way down to the tiers that are needed. So there are significant limitations as it is currently planned for right now.

Senator BINGAMAN. Mr. Torelli, is this DINET the best thing we have? If so, what does it do?

Mr. TORELLI. The DINET system is a prototype, it is what we have right now. We are working on a plan to determine how far we need to go.

Mr. Math correctly described that the system isn't just for foreign dependency; it is to analyze the who, what, and where in the entire bill of materials for programs. There may not have been a good match between the concept and its implication. But, we had a lot of "help" with people offering data bases of several different kinds, and I think that caused a lot of hiccoughs in the implementation. It created a situation where we were trying to determine which was better.

What I am doing right now is having my production base staff develop a detailed plan for how we evaluate and implement this system.

Senator BINGAMAN. When would you expect that plan to be concluded so that we could see it?

Mr. TORELLI. I really don't know that, sir, and I will get back to you for the record on that.

Senator BINGAMAN. Is it something that you would expect in a few months or a few years?

Mr. TORELLI. I don't think the plan can wait a few years. Again, this DINET, in my estimation, is part of the strategic plan that I addressed earlier in terms of my organization and how it fits within the acquisition process.

[The information follows:]

DINET

As I mentioned, DINET is now in an operational prototype stage and is being utilized in support of a number of functions. For example, it was used during Desert Storm to help identify sources for items like barbwire and gas masks and it is routinely utilized to conduct industrial base impact assessments in connection with filings with the Committee on Foreign Investment in the United States (CFIUS). I believe DINET can play an important role in support of a number of acquisition-related issues but contrary to some perceptions, it is not the end-all solution. Information is key to understanding and developing solutions and my initial impression is that the DINET data base initiative has the potential to be a useful resource. I envision that DINET will evolve as we continue to structure a strategic plan consistent with acquisition process improvement. Our primary concern at the moment is to enhance our visibility into the subtier base and to better understand the extent of foreign sourcing. A number of data bases have already been identified and we are accelerating our efforts to include this capability in the DINET system. We are also revising DOD Industrial Base Policy issuances to integrate DINET more directly into a new Industrial Preparedness information collection process. These are major steps in the evolution of a usable and affordable data base support capability. We are giving this priority attention and I fully expect to make significant progress in the coming year.

Senator BINGAMAN. You also talked in your statement about an effort to tie these DOD critical technologies into critical industries and then, presumably, tie those to components so that you would have some basis for determining what you needed to have a domestic capability for and what you didn't. Is that all part of this same deal?

Mr. TORELLI. That's the same plan that I'm working, yes, sir. And that is within my organization. We go off-site next month to kick off that process and make it move. So it will be the same timeframe, I would say, because DINET will be a piece of the overall plan.

Senator BINGAMAN. We also asked you last week about this Defense Manufacturing Plan that we directed that you do. It would seem to me that phase 2 might relate.

Mr. TORELLI. Absolutely. I want to thank you for helping steer us to develop a plan that doesn't just sit on a shelf, but one that is used. Discussions again this morning talked about accountability and having people with measurable goals. Part of the plan, as I intend to do it and as I did it in industry, is to get it to the point where we have measurable goals at the management level for my organization, and also be able to filter those goals back out to the services for where we are going with this entire plan.

It is, I won't say simple, but it is a flowdown. I see an interrelationship of the critical industries, critical technologies, manufacturing technology, computer-aided acquisition logistics support, and DINET—all supporting the acquisition process. And, as those things all fit together, there is going to be some natural synergy in terms of how those things will integrate and work together.

Senator BINGAMAN. I believe Mr. McMillan testified that we would not see this plan on manufacturing until the end of the fiscal year. The first of October is the date that I recall.

Mr. TORELLI. That is about right.

Senator BINGAMAN. Is it realistic to think we could see this other one before that?

Mr. TORELLI. No, sir. The strategic plan, as I said, kicks off next month. I have been through this process before. It is a good 6-month process to get it together and solidified. I am not sure I'm ready to commit to something yet because it has to be somewhat fluid in terms of the environment. But it is a goal, it is a way to go. And, as I said earlier, it shows the integration because there are too many pieces that do correlate and link to go off in different directions.

Senator BINGAMAN. Let me shift to a different subject. In procurement, one of the issues I think you mentioned in your testimony is that DOD needs to use contractor past performance in deciding which contractors to use. A couple of years ago, we put some provisions in the law directing DOD to access this Air Force Blue Ribbon contracting program and use that same program DOD-wide. Has that been done?

Mr. **Torelli**. There are initiatives going on. I have seen one in the Army very similar to the Blue Ribbon program that the Air Force has. This particular Army program was impressive in the way of going for best value.

The goal, from my perspective, is to convince the contracting officers, convince the service acquisition executives that best value is the way to go. We all acknowledge that common sense says that you want to buy the best you can get, not necessarily the cheapest.

Senator **Bingaman**. Has DOD directed the services to implement this program? Are you saying that the Army has also decided to do it?

Mr. **Torelli**. Every service is off doing this initiative right now. As far as a directive is concerned, I can't recall one right now. Again, I will check and supply something for the record in terms of a directive.

[The information follows:]

PROGRAMS

DOD has not directed the services to implement such a program—it has not been necessary. Programs based on the same concepts as the Blue Ribbon Contractor Program have been started in each service and in the Defense Logistics Agency. For example, the Defense Industrial Supply Center has implemented a "Quality Vendor Program," and the Air Force has expanded its "Competition for Performance" program (the successor to the Blue Ribbon Contractor) to the entire service. These programs have been generally successful in buying best value and, interestingly, although they authorize the contracting officer to pay more for supplies from a top quality contractor, that has rarely happened. In most instances the lowest priced contractor has also been one of the "Blue Ribbon" Contractors.

Senator **Bingaman**. Senator Smith.

Senator **Smith**. I have nothing more.

Senator **Bingaman**. I think we have a lot of additional things that we need to follow up on, but rather than prolonging the questions I want to thank you both. I think it has been useful. We have got a lot of issues here that seem to be in the very formative stage, and I hope that is not the way they remain. They have been in that condition during the 8 years that I have been in Congress. I hope we can move it along.

Again, I appreciate your willingness to testify. The hearing is concluded.

[Additional prepared statement submitted by the Shipbuilders Council of America follows:]

PREPARED STATEMENT SUBMITTED BY JOHN J. STOCKER, PRESIDENT, SHIPBUILDERS COUNCIL OF AMERICA

Mr. Chairman, members of the subcommittee, I am John Stocker, President of the Shipbuilders Council of America. The Shipbuilders Council is the national trade association which represents private shipyards and suppliers of marine equipment and services. A membership list is attached to my statement.

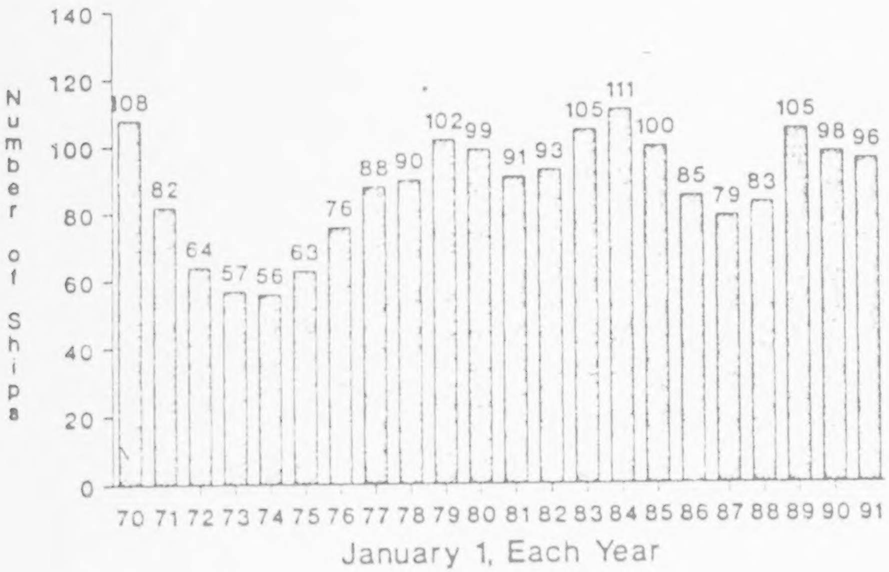
In 1978, the shipbuilding and repair industry had a healthy backlog of ship work for both our military and commercial customers. The industry had under contract 60 ships for commercial customers and 60 ships for the U.S. Navy. Today, the industry has 96 naval vessels, and only three commercial ships under construction.

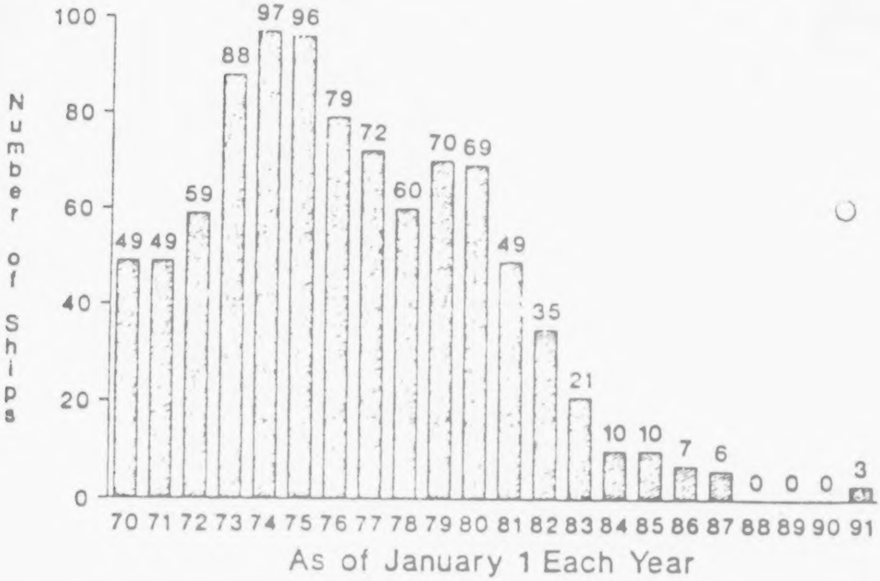
During the 1980's, in spite of the largest naval peacetime buildup in the Nation's history, our industry lost one-third of its capacity. In 1981, the industry employed 186,700 employees compared to 129,300 today. This represents a loss of 57,400 jobs.

The industry's decline is due to the near total collapse of commercial shipbuilding in this country. In 1981, the U.S. Government made the decision to terminate Construction-Differential Subsidies (CDS) for the building of commercial ships in U.S. shipyards. That decision was made without considering the effect on the U.S. shipyard industrial base, and without pursuing the elimination of foreign government subsidy practices.

The following charts track the number of commercial and Navy ships on order or under construction in U.S. yards since 1970.

NEW NAVAL VESSELS UNDER CONSTRUCTION OR ON ORDER AT U.S. PRIVATE SHIPYARDS





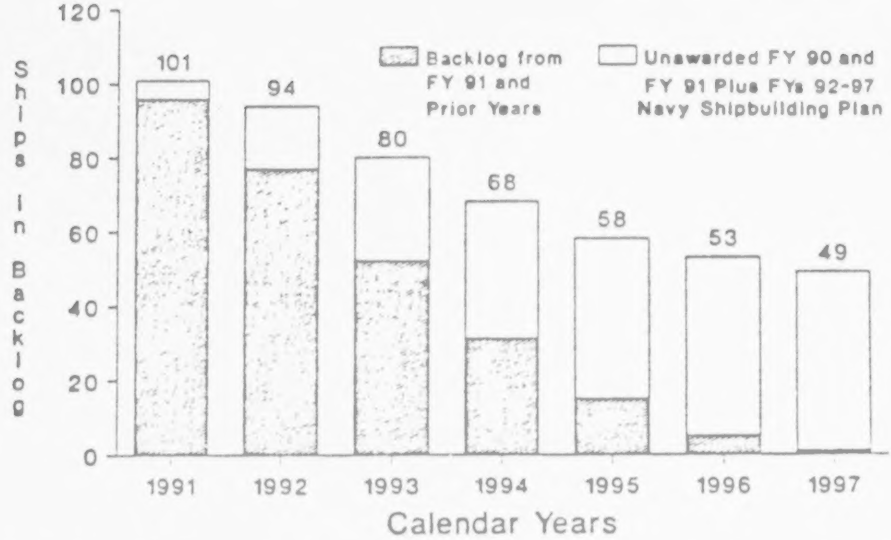
NEW MERCHANT VESSELS UNDER CONSTRUCTION OR ON ORDER AT U.S. PRIVATE SHIPYARDS

Our industry now enters a new era. The days of healthy defense budgets are over, and there is no commercial shipbuilding, of any consequence, underway in this country. The Navy's shipbuilding and conversion plan over the next 6 years averages less than 10 ships per year. Ongoing Navy construction provides business for 13 yards. Six of the 13 yards have less than 2 years of ship construction remaining under contract. Shipyards engaged in ship repair will also see their work diminish as the Navy reduces its force levels from 559 ships in fiscal year 1987 to 450 in fiscal year 1995. For an industry almost totally dependent on the Navy for its survival, this structural budgetary change will be catastrophic.

Acquisition of only one nuclear submarine per year—the SSN-21 Seawolf—will not sustain two nuclear submarine production yards. Termination of the LHD-1 program in fiscal year 1991, means Ingalls Shipbuilding will be almost totally dependent on the construction of destroyers, as is Bath Iron Works, for its livelihood. The LCAC program, slated for termination in fiscal year 1992, is the principal source of business for Textron Marine. LCAC construction is also important to Avondale Industries. What will be the future for Peterson Builders and Marinette Marine after the last of the MCMs are delivered to the Navy?

The chart below projects that by 1997, there will be only 49 Navy ships on backlog in U.S. shipyards.

PROJECTED BACKLOG OF NAVY SHIPBUILDING



It is clear that many of the new construction yards are in business today solely because of their backlog of ships under construction from prior year Navy budgets. Once these ships are delivered—and with no follow-on ship procurement plans—these yards will close. The same fate will beset the yards dedicated to the repair of naval ships as ship repair availabilities also will decrease.

In testimony before this subcommittee, Navy Assistant Secretary Gerald Cann stated that—and I quote—"many jobs will be lost and some shipyards will have to find other work or close". It is important that DOD and the Congress understand what finding other work—meaning commercial work—entails.

U.S. shipyards are probably the most flexible in the world. Few, if any, shipyards exist in foreign countries which have experience in building both commercial and Navy ships. To be competitive—in either market—a shipyard is either a producer of commercial ships or a producer of naval ships. On the other hand, there is not a U.S. shipyard today which has not had experience in both markets at some time during its history. When commercial shipbuilding collapsed in this country, the shipyards which survived the 1980s had to transition themselves back into the naval construction business. This was not an easy task, and many were unsuccessful.

Penn Ship which was the former Sun Ship in Chester, PA, is a recent example of a yard which could not make the transition from commercial to Navy work. Conversely, the U.S. Navy would not have had the luxury of a U.S. shipyard with the facility and capability to build large aircraft carriers had it not been for the investment made by Newport News Shipbuilding to meet commercial market demands. The facility investments made at Newport News were made to build very large crude carriers (VLCCs) for the commercial market. When the commercial market collapsed, their facilities were there for the benefit of the U.S. Navy.

Why is commercial and Navy construction work so different? The entire company must be restructured. Management, manufacturing process, and facility structure must be changed to build a very different product for a very different customer. To better explain the differences, let me begin with the product.

PRODUCT DIFFERENCES

Ships built for the U.S. Navy are generally sophisticated and often very specialized to their mission requirements. Naval combatant ships must be light displacement, and militarily survivable, with many small compartments, high shock resistance, low noise radiation, stealth features for minimum radar and infra red cross section, and highly maneuverable. In order to meet its combat mission, the ship's military capability is vital. This means that specialized materials—such as thin scantling high strength steel—are required. Their outfitting is extremely complex. Many ships compartments are filled with high technology navigation, communication, machinery plant, and weapon system equipment. Combatant system technology is continuously improving requiring the ship design to evolve during the construction period of a series of ships. Seldom are two ships of a class identical.

Conversely, a commercial ship is designed with fewer, larger compartments which are less crowded with outfitting. The hull steel scantlings are thicker. The construction units are much larger. An oil tanker, for example, has 50 percent of its shipyard construction work related to steel versus only about 10 percent steel in a Navy combatant. The best analogy is the construction of a Corvette versus a Mack Truck. The Corvette is sleek, light weight, all space is well utilized, with none to spare, and it is a high performance automobile. A Mack Truck is huge, with wide open spaces for the carriage of goods, it is not designed for high performance. It is heavy. The manufacturing process for a Mack Truck is very different from that of a Corvette. You can't build Mack Trucks in a Corvette assembly facility.

SKILLS

The make up of the work force is also very different. A relatively high proportion of combatant shipbuilding requires the electrical/electronic trades. In the construction of naval ships, a shipyard needs large numbers of electrical technician specialists to integrate all the high tech weapons, navigational, and communication systems. A relatively larger number of pipefitters and machinists are also required. For building commercial ships, a shipyard needs more workers trained in the steel trades, such as welding and shipfitting versus the outfitting trades.

MANAGEMENT

To do business with the U.S. Navy, a shipyard must employ a cadre of "management" personnel. These people are essential to fulfilling military contract requirements, such as meeting special cost accounting standards and detail military quality assurance configuration management, customer relations, and national security requirements. Last, but not least, are the myriad of data requirements; the so-called CDRL or Contract Data Requirements List makes data provision as important as the ship itself. These "management" requirements are very timely and costly.

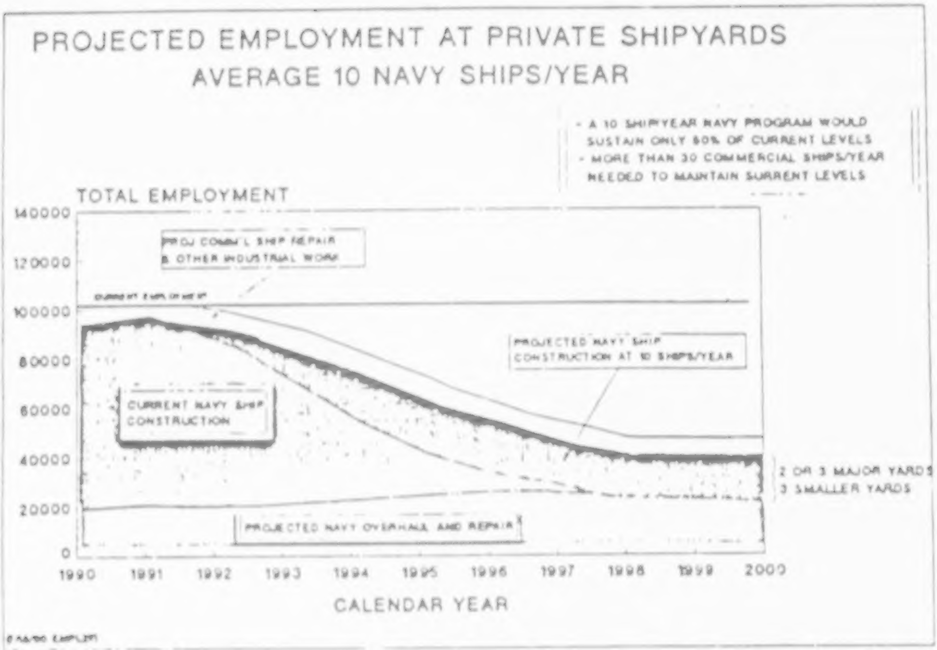
In the commercial market, the customer is interested primarily in the finished product—not looking over your books or inspecting how your workforce welds two plates of steel together. A shipyard quotes a price, schedule, and quality for a product—period. The customer wants that product, for that quality, at that price, and on that schedule. The commercial client isn't interested in overseeing the day-to-day business operations of the company to see how that product was made.

In a rather simplistic way, I have tried to explain the differences between commercial work and naval work to emphasize that a company dedicated to building naval ships cannot, overnight, just pull a lever and be competitive in the commercial market—or vice versa. It is a costly, painful, and time-consuming proposition to convert from military business to commercial and then back again.

IHaving said that, given current national policy and the 6-year budget for the Navy, more shipyards will close, and more jobs will be lost. Do not doubt this reality. It could be the case that by the late 1990s, the United States will have perhaps two or three very specialized, and downsized, shipyards dedicated to the construction of sophisticated ships for the Navy—such as destroyers, submarines, and aircraft carriers. Perhaps two or three other shipyards will survive to build a combination of some auxiliary; mine-countermeasure ships, and oceanographic ships for the Navy. The future of private shipyards engaged in naval ship repair is just as bleak. In other words, there will not be much of a shipbuilding, and repair, and supplier industry left in the United States by the end of the decade.

The Navy determined in July of 1990, that a 10-ship per year new construction program and related repair work would support a workforce of only 50,000 employees by the year 2000. If the current shipyard base is to be sustained, the Navy estimates that more than 30 commercial ships per year would be needed.

The following chart, produced by the U.S. Navy, illustrates the anticipated decline in our industry.



The question that we are left with is the following: Should the Nation care? Should this subcommittee care? The Secretary of the Navy, Garrett, had this to say on the subject before the full House Armed Services Committee this year:

"The United States cannot maintain strategic advantage without a credible, capable industrial base. The capability to expand substantially our shipbuilding may well be necessary in the future. The strength of our national industry is as important to the national security as our military forces. To be able to reconstitute forces, we need a vibrant industrial base. Its competitiveness must also be a priority."

If Secretary Garrett's concerns are to be alleviated, the following is required:

(1) Elimination of foreign shipyard subsidy practices. If a shipyard is to make the commitment to transition itself back into the commercial market, foreign government subsidies must be eliminated. U.S. shipyards cannot compete with foreign governments. The Office of the United States Trade Representative (USTR) has been engaged in negotiations to end foreign shipbuilding and repair subsidy practices for 21 months. This committee should urge DOD to take an active role in assisting USTR achieve this goal. If negotiations fail, Congress and the U.S. Government must be prepared to take unilateral action. A ship built or repaired with subsidies should not be allowed to enter a U.S. port until the subsidy used in that ships construction or repair is paid to the U.S. Government.

(2) Funding for modern, efficient, roll-on/roll-Off (RO/RO) ships, and tankers to meet the Nation's sealift requirement is essential. Operation Desert Shield proved—what Congress and this industry had been saying for years—that the Nation has a serious sealift shortfall. Historically, DOD has been unwilling to pay for sealift—even though it is a DOD requirement. Congress has taken the lead in authorizing and appropriating a total of $1.3 billion in fiscal year 1990 and fiscal year 1991 to begin to redress the sealift shortfall.

A multi-year sealift construction program is vital to this industry's transition from complete military dependence to the commercial market. A 5-year program to build sealift ships to commercial specifications will provide those shipyards, interested in making the transition to the commercial market, with the means to do so. It is in the Navy's best interest that these yards are successful in the commercial market if the companies and facilities are to be preserved to serve future military requirements. An add-on to the SCN account in fiscal year 1992 of $1 billion for sealift is urged.

(3) Oppose the acquisition of foreign-built ships to meet the sealift requirement. DOD and the Navy will shortly come to Congress and request the authority to use a portion of the $1.3 billion authorized and appropriated for sealift to acquire used

RO/ROs off the international market to meet the sealift requirement. Let me assure this subcommittee—there is not one foreign-built RO/RO available that was not constructed without the assistance of foreign government subsidies. How would such an acquisition policy assist the Office of the USTR in trying to negotiate an agreement—with the very subsidizing governments of these ships—to end such unfair trade practices? What impact would such a policy decision have on the industrial base—which the U.S. Navy has stated is essential to the security of this Nation?

USTR is already negotiating from a position of weakness, since this country unilaterally terminated the Construction Differential-Subsidy to its shipyards in 1981. To now reward those continuing subsidy practices—which by the way total $4.5 billion in planned, budgeted, or dispersed subsidies by the governments of Japan, Germany, and Korea in the last 18 months alone—by granting foreign companies access to the U.S. defense market is ludicrous. Sealift carries 95 percent of all military equipment, while airlift carries 5 percent. DOD does not propose that the United States should buy used, antiquated aircraft from the international market to meet its airlift requirement. Instead, it plans and budgets over $40 billion for the development and acquisition of a modern and efficient aircraft. Is it so outlandish for DOD to spend $5 to $7 billion on a multi-year sealift program to meet 95 percent of its lift requirements?

(4) Promote the export of combatant ships. Export business would reduce the overhead cost of those shipyards which continue to be producers for the Navy, and thus, reduce the price of naval ships for the U.S. Government. U.S. shipyards build the most sophisticated naval ships in the world. Most of our allies do not want or need the degree of sophistication that the American Navy demands. However, there is a tremendous export opportunity for less sophisticated naval ships. U.S. shipyards could excel in this market—but they need the assistance of the U.S. Navy in helping to identify the needs of our allies, and in encouraging—rather than discouraging—their participation in this market.

Furthermore, the U.S. Government provides its allies with Foreign Military Sales (FMS) credits—provided those countries spend the credits for weapon systems produced in the United States. Our allies do not have a need for nuclear submarines. They want diesel electric submarines. They want less-sophisticated but capable small surface combatants. Unfortunately, Navy policy prohibits any U.S. shipyard from building a diesel-powered submarine for export. The reason is well known. The Navy is concerned that Congress would abandon support for nuclear submarines for the U.S. Navy inventory. The same concern has been expressed about surface combatants, as well. This industry is confident that Congress recognizes the technological requirements of the U.S. Navy—which far exceed the navies of our allies. We simply urge you to urge the Navy to allow us to build diesel submarines for export. This market would help to sustain the industrial base in times when U.S. Navy demand for new ships is on the wane. It would also reduce the shipyard's overhead, which would reduce the price of ships financed by the U.S. taxpayer. Most importantly, it would insure that U.S. taxpayer dollars allocated to FMS credits were spent on products produced in this country rather than elsewhere.

In summation, our industry urges you—as members of this subcommittee—to help us educate your colleagues on the short-sightedness of these policies to which I have referred. We need your help in urging the Navy and DOD to reconsider these old policies, and to bring future actions and policies in line with DOD long-term interests and requirements.

Regular Members

The American Ship Building Company, Tampa Shipyards, Inc., Lincoln Pointe Building, Suite 800, 2502 Rocky Point Road, Tampa, FL 36607.

Atlantic Marine, Inc., 8500 Heckscher Drive, Jacksonville, FL 32226.

Avondale Industries, Inc., Post Office Box 50280, New Orleans, LA 70150

Bath Iron Works Corporation, 700 Washington Street, Bath, ME 04530.

Bender Shipbuilding & Repair Company, Inc., P.O.Box 42, 265 S. Water Street, Mobile, AL 36601.

Bethlehem Steel Corporation, Bethlehem, PA 18016; Port Arthur, TX; Sparrows Point, MD.

Bollinger Machine Shop & Shipyard, Inc., P.O. Box 250, Lockport, LA 70374.

Edison Chouest Offshore, North American Shipbuilding, Inc., East 118th Street, Galliano, LA 70354.

General Dynamics Corporation, Pierre Laclede Center, St. Louis, MO 63105; Electric Boat Division, Groton, CT; and Quonset Point, RI.

General Ship Corporation, 400 Border Street, East Boston, MA 02128.

Halter Marine, Inc., 14055 Industrial Seaway Road, Gulfport, MS 39501.

Ingalls Shipbuilding, Inc., Post Office Box 149, Pascagoula, MS 39567.

Intermarine U.S.A., P.O.Box 3045, Savannah, GA 31402.

The Jonathan Corporation, P.O.Box 1839, Norfolk, VA 23501.

Marine Hydraulics International, Inc., 543 East Indian River Road, Norfolk, VA 23523.

Marinette Marine Corporation, Fly Street, Marinette, WI 54143.

McDermott Corporation, P.O.Box 60035, 1010 Common Street, New Orleans, LA 70160.

Metro Machine Corporation, Box 1860, Norfolk, VA 23501.

National Steel & Shipbuilding Company, Harbor Drive at 28th Street, Post Office Box 85278, San Diego, CA 92138.

Newport News Shipbuilding, 4101 Washington Avenue, Newport News, VA 23607.

Norfolk Shipbuilding & Drydock Corporation, Post Office Box 2100, Norfolk, VA 23501.

Peterson Builders, Inc., 101 Pennsylvania Street, Post Office Box 47, Sturgeon Bay, WI 54235./

Robert E. Derecktor of Rhode Island, Inc., Coddington Cove, Middletown, RI 02840.

Service Engineering Company, Pier 38, P.O.Box 7714, San Francisco, CA 94107; San Diego, CA.

Southwest Marine, Inc., Foot of Sampson Street, Post Office Box 13308, San Diego, CA 92113; San Francisco & San Pedro, CA; Northwest Marine Div., Portland, OR.

Textron Marine Systems, 6800 Plaza Drive, New Orleans, LA 70127.

Todd Shipyards Corporation, Corporate Office, 1102 S.W. Massachusetts, Seattle, WA 98134; Galveston, TX.

ALLIED INDUSTRIES MEMBERS

ABB Combustion Engineering System, 1000 Prospect Hill Road, Windsor, CT 06095-0500.

Bird-Johnson Company, 110 Norfolk Street, Walpole, MA 02081.

Centrico, Inc., 100 Fairway Court, Northvale, NJ 07647.

Fairbanks Morse Engine Division, 1730 M Street, NW, Washington, DC 20036.

General Electric Company, 1331 Pennsylvania Avenue, NW, Washington, DC 20004.

Hopeman Brothers, Inc., Post Office Box 820, Waynesboro, VA 22980.

IMO Industries, Inc., 3450 Princeton Pike, Post Office Box 6550, Lawrenceville, NJ 08648.

Jamestown Metal Marine Sales, Inc., 4710 Northwest Second Avenue, Boca Raton, FL 33431.

Jered Brown Brothers, Inc., 1300 Coolidge, Post Office Box 2006, Troy, MI 48007.

Lake Shore, Inc., Post Office Box 809, Iron Mountain, MI 49801.

SPD Technologies, 13500 Roosevelt Boulevard, Philadelphia, PA 19116.

Sperry Marine, Inc., Aerospace & Marine Group, Route 29 North, Charlottesville, VA 22907.

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South Tidewater Association of Ship Repairers, Inc., Post Office Box 5637, Chesapeake, VA 23324.

[Additional prepared material for the hearing record follows:]

THE UNDER SECRETARY OF DEFENSE,
ACQUISITION,
Washington, DC, July 9, 1991.

Hon. JEFF BINGAMAN,
Chairman, Defense Industry and Technology Subcommittee,
U.S. Senate,
Washington, DC.

DEAR MR. CHAIRMAN: Enclosed are the responses to the series of questions on current acquisition issues that you requested in your May 13, 1991 letter. I trust our responses will be helpful to you and your staff.

Sincerely,

COLIN MCMILLAN,
Acting USD(A).

Enclosure.

1. COMMERCIAL AND NON-DEVELOPMENTAL ITEMS

a. Please describe the Department's actions to implement, and to assess the implementation of the following items required by section 824 of the National Defense Authorization Act for Fiscal Years 1990 and 1991:

Question 1a(1): The simplified uniform contract for the acquisition of commercial item.

Response: The simplified contract for commercial products was published in the Federal Register on April 23, 1991. The new regulations make significant changes to customary procurement practices which should encourage suppliers to offer commercial items to satisfy DOD requirements. The new regulations:

— Prohibit government specified quality systems or quality programs;

— Severely restrict government in-plant inspection;

— Prohibit the use of government specified designs, manufacturing processes or procedures,

— Prohibit the use of military standards or military specifications that would impede a commercial supplier's ability to satisfy a DOD requirement;

— Require packaging and marking in accordance with commercial practices;

— Severely limit the acquisition of technical data;

— Require commercial computer software to be acquired under the same licensing agreements provided to the public;

— Restrict the number of government clauses contractors must flow down to their subcontractors and suppliers;

— Significantly reduce the number of contract clauses that may be used in a DOD contract for commercial items.

Question 1a(2): The guidance on subcontract clauses.

Response: The new regulations provide that a prime contractor shall not be required to include in its contracts with subcontracts and suppliers, or to require its subcontractors and suppliers to include in their contracts with lower tier subcontractors and suppliers, any contract clauses except: (i) clauses required to implement provisions of law applicable to such contracts; and (ii) clauses determined by the Secretary of Defense to be appropriate for such contracts. Contracting officers may require prime contractors to flow down only 29 FAR and DFARS clauses to their first tier subcontractors. A maximum of only 23 FAR and DFARS clauses may be included in contracts below the first tier.

Question 1a(3): The modified inspection clause.

Response: The new regulations make significant changes to traditional government inspection requirements. The regulations provide that in-process inspection shall be performed by the contractor in accordance with the contractor's standard practice. Government inspection of commercial items is limited to verifying that items tendered for acceptance conform to contractual requirements. DOD will not perform any inspection or testing prior to the time the items are tendered for acceptance. However, when it is determined that a commercial item to be furnished under a contract has a critical application, contracting officers may tailor inspection requirements.

Question 1a(4): The guidance on use of standard commercial warranties.

Response: The regulations provide that commercial items shall be acquired with the warranties provided to the public as customary trade practice if the customary trade practice warranties adequately protect the government's interest. Tailored warranties will be considered when customary trade practice warranties do not adequately protect the government's interests or when a warranty is not customarily offered to the public but is necessary to protect the government's interests. The new regulations also provide that contracts for commercial items that are weapon systems (e.g., not sold in substantial quantities to the general public) must comply with 10 U.S.C. 2403.

Question 1.a(5): The application of the Truth in Negotiations Act.

Response: We published a proposed FAR rule on September 6, 1990 to implement section 824(b) and simplify the process for claiming exemptions to the Truth in Negotiations Act. We received 266 public comments, which are still being analyzed by an ad hoc committee of DOD and civilian agency representatives. We anticipate publishing a final FAR rule by August 1991.

Question (6): The analysis of impediments to the acquisition of non-developmental items (NDI).

Answer: The analysis of impediments has been completed and is in the final stage of coordination prior to being signed out by the Under Secretary of Defense for Acquisition.

Question (7): The training for acquisition personnel in the acquisition of non-developmental items, including a description of the personnel that have and will receive the training.

Answer: The Department of Defense has developed a 2-day training course specifically on the acquisition of nondevelopmental items. By the end of June, we will have taught 20 classes (approximately 500 personnel) at the following buying activities:

U.S. Marine Corps Research, Development and Acquisition Command, Quantico, VA
Naval Sea Systems Command, Arlington, VA
Space and Naval Warfare systems Command, Arlington, VA
Communication and Electronics Command, Ft. Monmouth, NJ
Army Aviation Systems Command, St. Louis, MO
Air Force Electronic Systems Division, Boston, MA
Air Force Logistics Command, Wright Patterson AFB, OH
Defense Industrial Plant and Equipment Center, Memphis, TN
Defense General Supply Center, Richmond, VA
Defense Personnel Support Center, Philadelphia, PA
Department of Navy (general), Arlington, VA
Naval Aviation Systems Command, Arlington, VA
Army Chemical R&D Center, Aberdeen, MD
Tank and Automotive Command, Warren, MI
Army Missile Command and Redstone Arsenal, Redstone, AL

Air Force Aviation Systems Division, Wright Patterson AFB, OH
Defense Industrial Supply Center, Philadelphia, PA
Defense Electronics Supply Center, Dayton, OH
Defense Fuel Supply Center and Defense Logistics Agency, Alexandria, VA
Air Force Communications Command, Scott AFB, IL

The personnel attending the training were from various functional areas within acquisition, including specification, testing, logistics, and contracting. We are currently in the process of scheduling 30 additional courses to be taught this calendar year.

Question (8): The demonstration program in the procurement of clothing items.

Answer: The Defense Personnel Supply Center has written commercial item descriptions for 20 clothing and textile items. To date 17 solicitations have been issued and 16 contracts awarded. Some examples of items included are briefs, undershirts, socks, and gloves.

Question (9): Revision of the Defense Federal Acquisition Regulation Supplement (DFARS) to emphasize drafting specifications for acquisition of commercial products in terms of function or performance specifications as opposed to the use of military specifications.

Answer: The Department of Defense has submitted a proposed change to the Federal Acquisition Regulation, Part 10, which contains the regulations governing specifications and standards. The proposed change emphasizes writing specifications in terms of function and/or performance characteristics, as well as writing specifications to foster the purchase of commercial products. The proposed changed has been approved by the Civilian Acquisition Council and will be published in the Federal Register for public comment this summer.

b. Section 824(c) required the Department to analyze impediments to the acquisition of non-developmental items and to consider whether the regulations governing the acquisition of commercial products should be expanded to include non-developmental items.

Last year, in response to questions about the Department's implementation of this requirement, DOD advised the committee that it had not yet completed its analysis. However, the Department's preliminary assessment suggested that it might be useful to maintain a separate set of regulations for the commercial product subset of non-developmental items while amending Part 7 of the Federal Acquisition Regulation to address the acquisition of non-developmental items.

Question (1): Is separate regulatory coverage on the acquisition of non-developmental items appropriate?

Answer: Separate regulatory coverage on the commercial subset of NDI, such as appears in Part 11 of the Federal Acquisition Regulation and the new interim rule, DFARS Part 211, is appropriate. Regulatory coverage on NDI as a whole is also appropriate, to ensure the statutory guidance is implemented fully. We have not identified a need for separate regulatory coverage on noncommercial NDI at this time.

Question (2): Has the Department taken action to establish such coverage?

Answer: Regulatory coverage on NDI as a whole has been included in the recently issued regulation on Defense Acquisition, DODD 5000.1, and Defense Acquisition Policies and Procedures, DODI 5000.2.

Question (c): What action has the Department taken to implement section 810 of the National Defense Authorization Act for Fiscal Year 1991 (requiring use of market research to enhance the use and acquisition of non-developmental items)?

Answer: DODI 5000.2, Defense Acquisition Policies and Procedures, requires that market research and analysis be conducted prior to the commencement of a development effort. How to perform market research is currently addressed in our 2-day course on buying NDI. In addition, we are preparing a handbook for acquisition personnel on performing market research; it will be published this summer.

Question (d): Generally, section 18 of the OFPP act (41 USC 416) provides that an agency may not establish a deadline for the submission of bids or proposals less than 30 days after the date the solicitation is issued. What is the Department's view as to the desirability of reducing this timeframe for the procurement of non-complex commercial items?

Answer: It should be possible to respond to a request for bids for non-complex commercial items in less than 30 days, and the Department would like to have the flexibility to reduce the timeframe when we believe it is appropriate. We are always seeking ways to reduce procurement lead time, and this could contribute to that effort. However, in most instances 30 days does not seem an unreasonable amount of time between issue of the solicitation and receipt of bids or proposals.

2. BID PROTEST

a. The General Accounting Office recently issued final regulations that are intended to preserve the informality currently associated with the bid protest process while also providing flexibility to use judicialized hearing procedures when appropriate. Please assess the potential impact of these changes on the defense acquisition process.

Response: The recently published revisions to the General Accounting Office's bid protest procedures serve only to make the process more cumbersome and expensive, and will have the effect of delaying the resolution of bid protests and further judicializing the entire process, to the detriment of both the government and industry.

b. What other changes would the Department recommend in the bid protest process?

Response: The Department of Defense recommends that the General Accounting Office return to more informal and timely procedures, in keeping with its statutory mandate to "provide for the inexpensive and expeditious resolution" of bid protests that was established by the Competition in Contracting Act, 31 U.S.C. 3554(a)(1). We recommend also that the Department of Defense be given the authority to resolve protests concerning the Department's purchases of commercial products.

3. CONTRACTOR PAST PERFORMANCE

In a report to the committee dated February 6, 1991, DOD evaluated the effectiveness of the Air Force Blue Ribbon Contracting program. The report described the program's success in terms of both contractor price and performance. The program only applies to negotiated, fixed-price contracts for spare parts that do not exceed $10 million.

What action is the Department taking to apply the benefits of this type of program throughout DOD to larger contracts, to different contract types, to procurements for other than spare parts (including service contracts), and in sealed bid procurements?

Response: The Air Force Blue Ribbon Contracting program is only one of many programs in use by the Army, Navy, Air Force, and the Defense Logistics Agency to collect or use information on contractor past performance. Many of these programs apply to different classes of contracts than the Blue Ribbon program. In order to enable buyers throughout the Department to obtain information on who within DOD is buying similar products or services and who has past performance information on a contractor of interest, the Defense Logistics Agency is establishing a Contractor Profile System.

4. INTEGRATED FINANCING PLAN

Section 801 of the National Defense Authorization Act for Fiscal Year 1989 requires DOD to submit to the Congress, no later than February 1990, a report recommending a financial analysis methodology for DOD studies of return on investment in the defense industry. In addition, DOD is required to submit annually an integrated finance plan that is structured to meet the long-term needs of DOD for industrial resources and technology innovation.

Question 4.a: What is the status of the financial analysis methodology study?

Response: The report of the advisory committee established to recommend a financial analysis methodology was submitted to Congress on June 3, 1991.

Question 4.b: What is the status of the integrated financing plan for fiscal year 1992?

Response: The integrated financing plan is currently being updated to reflect changes in the Department's method of establishing progress payment rates, changes in the method for establishing the DOD cap for the negotiation of advance agreement ceilings for contractor independent research and development/bid and proposal costs, and revised guidance for the use of fixed- or ceiling-priced production options obtained before the start of full-scale development contracts. We expect the updated integrated financing plan to be furnished to the Armed Services Committees within the next 60 days.

5. ACQUISITION WORKFORCE

Please describe the status of the implementation of the following acquisition workforce incentives authorized by Congress last year. For each incentive, please include the projected number of individuals expected to receive the incentive within the Department of Defense for each of fiscal years 1991 and 1992.

a. Degree training (section 1206(a) amends 5 USC 4-107): The Office of Personnel Management (OPM) has provided a draft revision of 5 CFR Part 410 to selected agencies for informal comment. The draft allows free use of the new authority where there is a previously defined recruitment or retention problem (e.g., special salary rates or direct hire authority) or where there is explicit statutory authority (e.g., the acquisition workforce). In other cases, the agency would have to specifically justify and document its determination of a recruitment or retention problem, and would have to make at least annual re-determinations. Final regulations are anticipated late fall.

b. Student loan repayment (section 1206(b), amends 5 USC S5379): OPM has provided a draft of a regulation to implement section 1206(b) to selected agencies for informal comment. The regulation would become a new part of the Code of Federal Regulations, specifically 5 CFR Part 537. The regulation has not yet been published in the Federal Register for formal comment. Draft would require agencies to develop a plan containing criteria for authorizing payment and amount, procedures for paying/verifying loans, system for selecting employees, requirements for service agreements, documentation and record keeping. Final regulations are anticipated late fall.

c. Critical pay authority (Federal Employees Pay Comparability Act (FEPCA)): Office of Management and Budget has issued interim regulations. The Department is now examining our need for critical pay authorizations in light of the Executive Level pay increase which became effective in January and other FEPCA features, e.g. new recruitment and retention bonus flexibilities.

d. Waiver of the penalty against further government service by retired personnel (FEPCA): This provides authority to employ military or civil service retirees without salary offset where there is exceptional difficulty in recruiting/retaining a qualified employee. OPM has issued interim regulations. On May 2, the Deputy Secretary of Defense delegated the authority to request dual compensation waivers for all DOD positions to the Director, Administration and Management. This delegation reflects the Department's desire for centralized review and approval of requests for waivers to ensure consistent and valid use of the authority. Procedures for making requests are under development.

There are no projections of the number of individuals expected to receive each incentive for fiscal years 1991 and 1992. A management information system is being developed to provide standardized information on persons serving in acquisition positions and to support annual reporting to the Congress. The report will include the number of persons in the acquisition workforce participating in the degree-training and student-loan-repayment incentives.

6. ACQUISITION WORKFORCE REDUCTIONS

a. The National Defense Authorization Act for Fiscal Year 1991 required DOD to reduce the acquisition workforce by 4 percent per-year through fiscal year 1991. Please describe the actions DOD is taking to implement this requirement in:

(1) Fiscal year 1991.

Response: The Deputy Secretary of Defense issued preliminary implementing guidance on this congressionally-directed acquisition work force reduction on November 7, 1990. The fiscal years 1992-1993 DOD President's Budget Request currently before the Congress includes proposed manpower reductions of approximately 550,000 military and civilian spaces between fiscal year 1990 and fiscal year 1995. Approximately one-fifth of this total programmed reduction can be attributed to the acquisition work force.

We believe that the Defense Department will meet the fiscal year 1991 congressionally-directed acquisition work force reduction target of approximately 23,000 military and civilian spaces.

(2) Fiscal years 1992 and 1993.

Response: The Defense Department will address any congressionally required fiscal year 1992 and fiscal year 1993 acquisition work force reductions upon receipt of final congressional action on the President's fiscal years 1992-1993 DOD budget request.

Arbitrary percentage reductions to the acquisition work force or to any other part of the Department's military or civilian manpower can be highly disruptive and counterproductive.

b. Section 609 of the Persian Gulf Conflict Supplemental Authorization and personnel Benefits Act of 1991 directs the Secretary to ensure that any facility that experiences an increased workload resulting from Operation Desert Storm should not be required to make a defense acquisition workforce reduction during fiscal year 1991 that would adversely affect the ability of that installation to perform its mission. Has the Department determined whether the workload at any DOD facility has increased due to the Gulf conflict?

Response: The workloads at many Defense Department facilities have increased as a result of Desert Shield/Desert Storm operations. However, most of the military and civilian manpower reductions in the President's budget request are directly related to programmed mission and workload reductions, and we believe that these reductions can still be accomplished without adverse impacts on mission accomplishment. If there are instances where congressionally-directed workforce reductions adversely affect the ability of a DOD activity or organization to complete its assigned missions, then the Department will notify the Congress.

7. DEFENSE MANAGEMENT REVIEW

a. Regulatory Relief Task Force

With respect to the Regulatory Relief Task Force established by the DMR to review regulatory and policy guidance concerning defense acquisition:

(1) What action has the Department taken to obtain the views of industry, academia, and professional associations on actions that should be taken as part of the regulatory relief effort?

Response: The Department has made a concerted effort to involve industry, academia, and professional associations in the regulatory relief effort. Members of our DMR implementation team have spoken at numerous conferences to acquaint the private sector with our regulatory relief goals and plans. These speaking engagements have lead to dialogue between us and individual companies and associations regarding how our efforts could be improved. We have taken industry's suggestions seriously. We have also established the panel authorized by section 800 of Public Law 101-510. That panel, chaired by Admiral Vincent who is the prospective Commandant of the Defense Systems Management College, is composed of outstanding individuals from industry, academia, and government. We look forward to receiving the results of their work.

(2) What has the Task Force accomplished to date?

Response: We have conducted a zero-base review of the DOD regulatory process to address the administrative and legal burden it places on the defense acquisition system. The review encompassed three major areas: Directives and Instructions, Procurement and Contracting Guidance (DFARS), and Military Specifications and Standards. Our review of 500 acquisition-related DOD-level Directives and Instructions identified almost 400 for cancellation, consolidation, or revision. To date, we have canceled nearly half of those recommended for elimination, and have developed drafts of various consolidated documents that will result in cancellation of over 100 additional policy documents. With the publication of the revised DODD 5000.1, DODI 5000.2 and DOD manual 5000.2-M on February 23,1991, we were able to cancel 50 DOD directives, instructions and manuals as well as 15 policy memoranda. We are now planning to ask the services to implement regulatory relief and will monitor the services implementation in order to ensure that regulatory burden is not created through supplementation. Similar efforts with other directives/instructions are taking much longer than initially anticipated. The revisions to the DFARS have focused on eliminating unnecessary policies, procedures or requirements, and making it as usable to the contracting officer as possible. As a result, the DFARS text and clauses have been rewritten in plain, user-friendly language. To date 27,288 lines of text and 113 clauses have been deleted with the release of four new DFARS for public comment. We plan to publish a complete new DFARS this summer. We will then submit a legislative proposal to obtain relief from burdens imposed on contracting officers and contractors by statue. We have completed our zero-based review of over 13,000 specifications and standards with the objective of eliminating guidance that unduly limits the flexibility of DOD suppliers. We have committed to canceling 4,968 standards, specifications, and handbooks. We will revise 8,879 standards, specifications, and handbooks. The focus of the revisions will remove excessive design detail, update for new technologies, and eliminate use of hazardous materials.

(3) What are the remaining goals of the Task Force?

This is an area where we still have major efforts underway and will for sometime. Certainly completing all of the actions identified by the Regulatory Relief Task Force (RRTF) is our most important remaining goal.

(4) What timetables have been established to achieve these remaining goals?

Response: In all three areas actions are underway to comply with the recommendations of the RRTF. This is an enormous undertaking to complete all these actions and we have learned that these efforts are taking somewhat longer to complete than we originally anticipated. During the next year the Deputy Secretary of Defense and I will focus heavily on the implementation of these initiatives.

Question 7.a(5): Will the Task Force undertake a substantive review of the DFARS?

Response: The Task Force completed a substantive review of the DFARS in December 1989. The Defense Acquisition Regulation System then completed a second review, independent from the Task Force, and eliminated 52 percent of the DFARS, including 113 clauses, and rewrote the remainder of the DFARS in plain English.

Question 7.a(6): In September 1989, representatives of industry associations requested a substantive review of 77 regulatory provisions that, in their view, inhibited sound business practices. What action has the Department taken to review these provisions?

Response: After combining common items, there were 74 areas of recommendation consisting of 101 separate actions to be tracked. At present, action has been completed on 74 of these actions. These completed actions break down as follows:

Actions Adopted	27
Actions Partially Adopted	11
Actions Not Adopted	36

Most of the suggestions that were not adopted violated statute, added significant administrative burdens, or contained insufficient justification to support their adoption. Twenty-seven (27) action items are still open, and their status is monitored on a continuing basis.

Question 7a(7): The Department advised the committee last year that it had identified over 200 DOD-level issuances for cancellation, consolidation, or revision. How many of these issuances have been acted upon to date? What timetables have been established for completion of this project?

Response: To date, we have canceled over half of those recommended for elimination, and have developed drafts of various consolidated documents that will result in cancellation of over 100 additional policy documents. These efforts are taking much longer than we initially anticipated. During the next year, the Deputy Secretary of Defense and I will focus heavily on implementing the recommendations of the Regulatory Relief Task Force.

Question 7.a(8): Last year the Department advised the committee that a new, proposed DFARS would be published for public comment in August 1990. What is the status of this effort?

Response: DOD met the deadline and published the first proposed rule for public comment in August 1990. The entire DFARS has now been rewritten and published for public comment and we are currently analyzing public comments. After we complete our analysis of public comments, we will prepare the final rule and publish the final DFARS this summer.

Question 7.a.(9): Last year the Department advised the committee that by December 1990 recommendations would be made concerning the review and revision of the entire index of defense acquisition specifications and standards and that a significant number would be canceled.

Question (a): What is the status of this effort?

Answer: All of the specifications and standards—over 35,000—were reviewed by the end of 1990 and recommendations were made regarding cancellation, revision, conversion to some simpler form of document, or retention. Nearly 5,000 were identified for cancellation—about 1,500 without replacement, the balance to be replaced by simpler forms of purchase descriptions or by industry standards. Almost 9,000 more documents were identified as needing revision.

Question (b): How many specifications and standards have been canceled?

Answer: Over 1,000 military specifications and standards were canceled during 1990. Additional documents are being canceled every day.

Question (c): Has an action plan with a timetable for all revisions been developed? If so, what are the timetables?

Answer: The process of cancellation, conversion to a different document type (such as a nongovernment standard) or revision can take anywhere from a few weeks to more than a year depending on the complexity of the document. All documents identified as needing revision, cancellation, or conversion have been scheduled for work, as resources permit, over the next several years.

Question 7.a(10): What actions has the Department taken to amend those provisions of the Federal Acquisition Regulation (FAR) that the Department maintains should not flow down to it? What is the status of these efforts?

Response: Those provisions which do not apply to DOD are clearly identified in FAR or DFARS as having no applicability to DOD.

Question 7.a(11): Has the Department taken action to establish a DOD control system to reduce the number of clauses that are included in solicitations?

Response: We have rewritten DFARS Part 201 to establish a system of controls. This system of controls calls for approval of the Under Secretary of Defense, as delegated to the Director of Defense Procurement, of all policies, procedures, clauses, or forms that have a significant effect on the public; all class deviations from the FAR or DFARS; certain categories of individual deviations; and department/agency control plans that cover one-time deviations and use of unique or special clauses.

7C. GOVERNMENT—INDUSTRY RELATIONS

(1)The DMR, noting that DOD ethics programs appear notably deficient, stated that a DOD Ethics Council will be chartered and the Under Secretary of Defense for Acquisition (USD(A)) will appoint an Executive Director to support the Council's efforts. Please describe:

(a) Organization and charter of the Council.

Response: The Defense Ethics Council was chartered (see DODD 5120.47). The Ethics Council comprises the Under Secretary of Defense (Acquisition) (Council Chair) and the Secretaries of the military departments. The Assistant Secretary of Defense (Force Management and Personnel), General Counsel, and Inspector General serve as advisors to the Ethics Council. The Council's activities are supported by an Executive Director, who also chairs the Joint Ethics Working Group. Working Group members are drawn from the acquisition and legal staffs of the services and the Defense Logistics Agency, as well as representatives of the General Counsel and Inspector General.

(b) Accomplishments of the Council to date.

Response: The Defense Ethics Council has issued a video, "DOD Ethics and Professionalism," based on case histories from the files of the DOD Inspector General. The video is being used in the field as part of an ethics awareness program to help DOD personnel understand their ethical responsibilities.

An ethics program that focuses on education and training for the acquisition workforce has been developed and is awaiting Ethics Council approval. The program is based upon ethical principles—integrity, honesty, and fairness—that underlie the standards of conduct required by law and regulation. The program will help acquisition schools provide better instruction in ethics; case studies are being developed by the Army War College and the Industrial College of the Armed Forces, and additional videos tailored to acquisition issues are under consideration.

(c) Council goals and implementation timetable.

Response: The Ethics Council's goals are to ensure that acquisition personnel are familiar with the standards of conduct and the underlying ethical principles; to improve their awareness of ethical issues that arise day-to-day; to increase understanding of how existing standards apply; and to recognize their responsibilities as moral leaders.

(2) The DMR stated that the Council would develop a model ethics program for DOD personnel that would include participation by the Secretary and Deputy Secretary. In addition, that Council would review existing programs to determine whether enhancements are needed and would establish demonstration programs to assess contractor compliance and enforcement of ethical standards. Please describe:

(a) The status of these matters.

Response: While not chartered members of the Ethics Council, the Secretary and Deputy Secretary have been very supportive of the Council's efforts to develop an ethics program that focuses on education and training for the acquisition workforce. The program is based upon ethical principles—integrity, honesty, and fairness—that underlie the standards of conduct required by law and regulation. The program will help acquisition schools provide better instruction in ethics issues and the responsibilities of managers to maintain a strong ethical environment in their organizations.

No comprehensive review of the Department's ethics programs has been undertaken since the Office of Government Ethics is in the process of publishing regulations that mandate significant changes to those programs. The Department of the Army has reviewed some of its compliance programs and made improvements in them. The DOD ethics program being considered by the Defense Ethics Council will address shortcomings in acquisition ethics education programs.

(b) Timetable for implementation.

Response: The implementation timetable will be to a large extent dependent on the regulations issued by the Office of Government Ethics.

(3) The DMR stated that "contractor self-governance remains the most promising additional mechanism to foster compliance with the high standards expected of

DOD's suppliers . . . [but] much remains to be done." (a) What actions has the Department taken to encourage more effective self-governance?

Response: The Under Secretary of Defense (Acquisition) addressed the 1990 Defense Industry Initiative on Ethics and Business Council (DII) Best Practices Forum, and challenged industry officials to take a more active leadership role in improving the ethical environment within their companies and industry as a whole. The 1990 conference also marked the first year that DOD officials joined industry members at the Best Practices Forum. In April 1991, the Acting Under Secretary of Defense (Acquisition) reaffirmed DOD's support for the accomplishment of the DII and asked the DII members to encourage all defense contractors and subcontractors to adhere to the high standards by the DII.

The Defense Contract Management Command is using performance based management—a concept developed to capitalize on contractor self-governance efforts—to determine the level of resources needed to perform contract administration.

(b) Is the Department planning additional actions to encourage contractor participation in programs such as the Defense Industry Initiative on Business Ethics and Conduct?

Response: The Department has used and will continue to use the Defense Policy Advisory Committee on Trade (DPACT) which consists of 35 CEOs of major defense firms, and other industry forums to encourage industry support of these self-governance programs.

(4) The DMR stated that "Like quality, ethics cannot be inspected into an organization. Accordingly, DOD will not adopt the rule recently proposed to mandate contractor codes of conduct." Please assess the effectiveness of actions by the defense industry to encourage contractor self-governance.

Response: While we believe that there is still room for improvement, 10 new companies became DII signatories in 1990, bringing the total to 55 companies, representing over 55 percent of defense prime contracting dollars. Also, over 400 companies have signed up to an ethics practices code developed by the American Electronics Association.

A review of the 1990 DII Annual Report to the Public and Defense Industry indicates that DII signatories have taken significant steps to improve their employees awareness of ethical issues and to ensure they recognize the importance of ethical conduct.

7. DEFENSE MANAGEMENT REPORT

Question 7.c(5): At a hearing last year, GAO testified that the Contractor Risk Assessment Guide (CRAG) Program is a good approach to restoring trust and confidence and reducing Government oversight. Representatives of industry outlined specific actions that DOD could take to enhance contractor participation in the program. Please comment on the manner in which each of the following could enhance such participation:

Response: Increased involvement of the ACO in the CRAG Process. Defense contractors who have implemented any section of the CRAG program know the ACO is the point of contact to begin that process and is a key participant in periodic progress meetings of contractor and government oversight representatives. A recent Defense Contract Management Command initiative to include CRAG in its efforts to streamline contract management services emphasized the ACO's proactive role. It directed area commanders and plant representatives to write letters to contractor chief executive officers about the benefits of CRAG. The initiative also highlighted the ACO's responsibility to inform and educate defense contractors about the CRAG program, and to assist those who wish to participate. We believe the initiative has enhanced contractor participation in the CRAG program.

Issuance of DOD-level guidance to ensure consistent and uniform application of CRAG. "The Contractor Risk Assessment Guide," dated October 1988, and its companion information booklet, "Contractor Risk Assessment Guide Program," dated November 1988, contain DOD-level guidance clearly stating that the CRAG program: is voluntary; was jointly developed by DOD and industry; provides a framework for defense contractors to demonstrate effective internal control systems; and facilitates improved DOD oversight and procurement processes. The guide also identifies a standardized set of control objectives and major controls agreed upon by industry and DOD.

Since 1989, we also have provided CRAG training to audit and contract administration field personnel, while industry and professional groups conducted a series of national educational workshops using DOD's CRAG training materials. Those actions augmented the CRAG guide to establish a common framework of understanding of the CRAG program among DOD and contractor personnel.

In August 1990, the Under Secretary of Defense for Acquisition sent a followup letter to top management of major defense firms. He reiterated DOD's commitment to the CRAG initiative and urged participation by those firms which had not yet elected to do so.

All of the foregoing policies, procedures, and actions were implemented to assure consistent and uniform application of the CRAG program and to enhance defense contractor participation. DOD-level support of, and policy guidance on, the CRAG program shall continue with that primary objective in mind.

Concentration by auditors on contractor system audits rather than analysis of individual transactions. DOD's review of defense contractor operations generally does entail the systems approach. That evaluation method, however, does not eliminate the need for transactions analysis. Some measure of transactions testing is needed to provide a level of confidence that the system under review is operating as designed. Of course, the more reliable a system appears to be (e.g., effective internal controls demonstrated under the CRAG program), the less transactions testing is required.

One area where the systems approach normally does not apply is that of individual bid proposals. Tests of proposed bills of materials, labor hours, and indirect rates generally are necessary to assure that the government obtains fair and reasonable contract prices and that provisions of Public Laws and Federal acquisition regulations have been complied with. A valid proposal evaluation could not be performed without the supporting evidence provided by transactions analysis.

Reliance on evaluation factors in addition to costs saved per auditor or audit dollar in the performance appraisals of auditors. Performance evaluations within DOD are not predicated on dollar savings. Performance is measured against elements and standards derived from each job description with emphasis on audit/review planning and adherence to regulatory and policy guidance. Since negotiated contracts are cost based, however, audits of selected contracts necessarily entail evaluating costs and questioning those deemed unsupported or excessive. Nonetheless, dollar amounts questioned indicate the quality of contractor representations in the contract proposal and negotiation processes, not the quality of audits performed.

Question 7.c(6): Has the Department evaluated the CRAG program to determine whether it produces a reduction in direct oversight, as opposed to merely reallocating audit resources within the audited activity? If so, what are the results of the evaluation?

Response: Due to the nature of the CRAG program, resource shifts among the various risk areas at a contractor location must logically precede a geographical relocation of resources. As with any program, the CRAG implementation process has required a certain amount of time to mature before concrete results became apparent.

Although the program was launched little more than 2 years ago, ample proof already exists that defense contractors who successfully implement the CRAG program do, in fact, realize tangible benefits. For example, one firm reported that DCAA recently reassigned 19 percent of its audit staff at one location: Although half of those reassigned were shifted from estimating system reviews to overhead audits, the other half were geographically relocated. Another more general example is DCAA's planned audit effort reduction of 26,000 hours during the current fiscal year, because of the successful efforts of contractors participating in the CRAG program. These examples demonstrate a reduced need for oversight where defense contractors' internal controls in one or more risk areas (i.e., indirect cost submissions, labor charging systems, material management and accounting systems, estimating systems, or purchasing systems) are adequate to meet regulatory requirements.

Several participating contractors have stated that, in an era of declining business opportunities, it is imperative that unnecessary costs be eliminated. Consequently, they have shifted resources internally to establish and maintain effective internal controls. They did so not because of expected oversight reductions, but because they consider it to be in their best interest to know how their systems operate and that the systems are producing the best output. Other contractors have said they view that kind of information as providing a competitive edge.

8. CONTRACTED ADVISORY AND ASSISTANCE SERVICES (CAAS)

The Department of Defense Inspector General recently issued a report on the adequacy of CAAS management controls. The IG found that DOD management controls need to be improved and made a number of recommendations for corrective action. Please describe the Department's plans and timetables with respect to implementation of the following recommendations:

a. Revision of DOD Directive 4205.2 including a supplemental pamphlet providing guidance prescribing procedures for CAAS acquisitions.

Response: A revised DOD Directive 4205.2 is planned for completion in September 1991. The information pamphlet is expected to be completed and ready for publication and distribution in September 1991.

b. Mandatory training for DOD and component personnel on the identification and reporting of CAAS.

Response: The revised DODD 4205.2 will assign responsibility to the component CAAS director for ensuring that a training program is in-place for component personnel who are involved in the management, acquisition or use of CAAS resources. The information pamphlet will be used as the basis for the training.

c. Revision of the FAR to eliminate the requirement that contracting officers make the determination whether contract services are CAAS.

Response: The issue of wherein lies the responsibility for determining CAAS is currently under review. The responsibilities of the sponsoring organization, the comptroller and the contracting officer regarding CAAS identification will most likely be changed in the revised DODD 4205.2. A change request to the FAR will be made as soon as possible upon determination of responsibilities.

d. A requirement that directors for CAAS acquisitions review such contracts that continue for more than 5 years.

Response: Since CAAS efforts are for nonrecurring or temporary requirements, we intend to include a policy statement in the revised DODD 4205.2 that specifically precludes using CAAS to meet requirements that continue for more than 5 years. We also intend to provide internal management control guidelines to be followed by CAAS review and approving officials that a contract for a CAAS requirement beyond 2 years should be carefully reviewed and in no instance be extended beyond 5 years.

e. Revise DODD 4205.2 to require that requests for CAAS contracts only be approved when cost comparisons demonstrate that such a contract is more economical.

Response: We did not concur in this DOD Inspector General recommendation. CAAS is used for nonrecurring or temporary requirements when suitable in-house capability is unavailable and development of in-house capability would not be cost effective because the special skills or expertise are not required full-time. If a cost comparison for long term requirements is appropriate—the requirement should not be met by the CAAS process but through the A-76 (contracting for commercial activities) process, or some other contractual arrangement.

f. Establish an estimated date for the issuance of guidance defining inherently governmental functions.

Response: The Office of Federal Procurement Policy (OFPP) is preparing to issue a policy letter for all government agencies providing guidelines for defining inherently governmental functions. The policy letter is currently in coordination and release is expected shortly. Upon receipt of the policy letter, the Department will publish implementing guidance within 90 days.

g. Preclude the use of indefinite quantity type contracts and options for CAAS acquisitions.

Response: We did not concur in whole in this DODIG recommendation. A blanket prohibition of a contract type for CAAS is not warranted. The choice of an appropriate FAR authorized contract type is the responsibility of the contracting officer. It would be unnecessarily restrictive on the prerogative of the contracting officer to remove an option without considering the circumstances of the particular procurement action. We realize the difficulties dated with indefinite quantity contracts, and as part of a CAAS policy memorandum to be issued soon, we will provide more explicit guidance for the use of this type of contract. This memorandum will also encourage the use of master agreements in the procurement of CAAS in accordance with 10 U.S.C. 2304(j), which authorizes a 3 year test program for these types of agreements. We will review our contracting courses to make sure that the appropriate use of all contract types are adequately covered. Also, we will recommend that decisions about contract type with respect to CAAS be made an item of special interest for future Procurement Management Reviews.

h. Issue guidance directing the increased use of fixed-price contracts in CAAS acquisitions.

Response: We plan to issue a CAAS policy memorandum by July which will include guidelines for the use of fixed-price contracts.

i. Issue guidance emphasizing the need to plan for competition in follow-on CAAS contracts.

Response: The CAAS policy memorandum will include a section directing the components to reemphasize the need for planning for competition in the awarding of initial as well as follow-on contracts.

j. Develop strategies to foster competition in CAAS small business set-asides.

Response: The CAAS policy memorandum will also address the use of presolicitation conferences. While we may generally recommend the use of such conferences to avoid single-source awards on small business set-asides, we cannot make such conferences mandatory. The unique circumstances of individual cases will determine whether such conferences can be held.

9. COMPETITIVE PROTOTYPE

10 U.S.C. 2365 requires DOD to use a competitive prototype program strategy in the development of major systems. This requirement sunsets on September 30, 1991. What guidance will the Department issue to govern the use of competitive prototypes after the legislative requirement expires?

Response: On February 23, 1991, the Department issued the new 5000 series guidance on the management of defense acquisition programs. That recent guidance, particularly DOD Instruction 5000.2 at Part 5, Section D, contains direction to use competitive prototyping to the maximum practicable extent in both major and nonmajor programs. Since this guidance is so recent, we do not anticipate a need to issue any new guidance on this subject following the expiration of 10 U.S.C. 2365.

10. ADVISORY PANEL ON STREAMLINING AND CODIFYING ACQUISITION LAWS

What is the status of the Advisory Panel on Streamlining and Codifying Acquisition Laws required to be established under section 800 of the National Defense Authorization Act for Fiscal Year 1991?

Response: This panel is receiving my careful attention and this will continue. The Chairman of the Panel is Admiral Vincent who is the prospective Commandant of the Defense Systems Management College (DSMC). Although Admiral Vincent reports for duty at DSMC early this summer, he has taken responsibility for the panel at this time. The other panel members have been identified and all have agreed to serve. Barring any unforeseen complications arising from information to be provided by the selected panel members to comply with Federal Advisory Committees Act requirements, the enclosed list will comprise the section 800 Panel. We believe that the membership of the panel is made up of outstanding talent from industry, government, and academia.

SECTION 800 PANEL MEMBERS

1. Pete Bryan, Deputy Director, Contract Policy and Administration, OUSD(A)DDP
2. Allan Burman, Administrator, Office of Federal Procurement Policy
3. Anthony Gamboa, Department of the Army—Deputy General Counsel (Contracting)
4. Jack Harding, Vice President Contracts, Raytheon Corporation
5. Leroy Haugh, Vice President Procurement and Finance, Aerospace Industries Association
6. Thomas J. Madden, partner in law firm of Venable, Baetjer, Howard & Civiletti
7. Ralph Nash, Jr., Professor of Law, George Washington University
8. F. Whitten Peters, partner in law firm of Williams & Connolly
9. Gary Quigley, Defense Logistics Agency—Deputy General Counsel
10. Major General John Slinkard, Deputy Assistant Secretary of the Air Force (Contracting)
11. Rear Admiral W.L. Vincent, USN (Panel Chairman), Prospective Commandant, Defense Systems Management College
12. Robert D. Wallick, partner in law firm of Steptoe & Johnson
13. Harvey Wilcox, Department of the Navy—Deputy General Counsel (Logistics)

11. ACQUISITION MANAGEMENT

The Air Force Systems Command (AFSC) has established a government/industry team to make recommendations to improve the Request for Proposal process. Does DOD have a mechanism in place to assess whether recommendations that have been successfully implemented by individual buying commands like AFSC are suitable for DOD-wide application? If so, please describe how this process operates.

Response: DOD has several mechanisms that bring good ideas and business processes to the attention of the Department, where the potential for broader application can be evaluated and implemented. These include:

1. Regularly held meetings between the USD(A) and the Service Acquisition Executives (SAEs). These meetings afford the opportunity to both discuss new ideas as well as implement those that are considered to have across-the-board application.

2. The monthly Interdepartmental Staff (IDS) meetings held by the Director of Defense Procurement with counterparts in the services and defense agencies. These meetings provide a forum to discuss new ideas, develop implementation strategies, and monitor implementation plans.

3. The Defense Acquisition Regulatory Council receives policy guidance from both the USD(A)'s SAE meetings and the IDS meetings and subsequently prepares regulatory coverage for DOD-wide implementation. In addition, the Defense Acquisition Regulatory Council accepts proposals from individuals in government and industry for DOD-wide consideration.

12. FIXED-PRICE DEVELOPMENT CONTRACTS

a. Section 807 of the National Defense Authorization Act for fiscal year 1989 prohibits the use of a firm fixed-price contract for the development of a major system over $10 million unless approved by the USD(A). This provision expired in October 1989.

The legislative history of section 807 stated that then existing regulatory coverage on the use of firm fixed-price development contracts did not provide sufficient guidance for the assessment of the relationship between pricing and program risk, and for the allocation of risk between the government and the contractor. The conferees directed the Department to establish clear guidelines concerning these matters.

Recent amendments to the DFARS (DAC88-16) provide that fixed-price research and development (R&D) contracts over $25 million must be approved by the USD(A). Generally, those below this threshold may be approved by the contracting officer.

Question 12.a(1): What specific guidance has the Department issued to comply with the legislative history of section 807?

Response: On January 31, 1989, the Department issued a new subsection, 235.006(70), to the Department of Defense Federal Acquisition Regulation Supplement. In addition, since then, in an attachment to a USD(A) letter of September 25, 1989, the Department has provided a list of questions that should be considered when assessing the appropriate type of contract for a development effort.

Question 12.a(2): What was the basis for setting the approval threshold for fixed-price R&D contracts at $25 million as opposed to $10 million as provided for in section 807?

Response: The $25 million threshold was established as Departmental policy in the Secretary's Defense Management Report to the President of July 1989. That policy was then implemented by a USD(A) letter of September 25, 1989, and has remained in effect since then. The choice of the $25 million threshold was based on the Department's experience with the provision in the fiscal year 1988 DOD Appropriations Act which required USD(A) approval for any fixed-price contract in excess of $10 million for development of a major system or subsystem. The Department found that this threshold was too low. It required USD(A) approval, with resulting delay and added work in the procurement process, for some contracts whose financial risk to industry was sufficiently low as not to warrant scrutiny at so high a level. The $25 million figure was then chosen as a better balance between the need to ensure that any potentially risky fixed-price development contract be subject to USD(A) approval and the desire not to impose a time-consuming high-level approval process when not needed.

It should be added that the section 807 threshold of $10 million applied only to firm-fixed-price contracts, not to all fixed-price type (fixed-price-incentive as well as firm-fixed-price) contracts as does the Department's $25 million threshold. Thus, while it may appear that the $25 million threshold is less inclusive, in reality it captures a great many more development efforts than the section 807 threshold. This is because most fixed-price development efforts are executed using fixed-price-incentive, not firm-fixed-price, contracts.

Question 12.a(3): How many R&D contracts were reviewed by the USD(A) when the threshold was set at $10 million?

Response: Since the establishment of an approval requirement in some form in late 1987, there have been 33 requests for approval. Of these 33 requests, 32 would have been required if only the Appropriations Act requirement were in force and 27 would have been required if only the Defense Management Report requirement were in force.

Question 12.a(4): By increasing the threshold to $25 million how many R&D contracts will no longer require USD(A) review?

Response: Please see the response to question (a)(3) above. If this experience were to continue in the future, there would be about 15 percent fewer approval requests under the $25 million threshold requirement alone than under the current Appropriations Act threshold of $10 million alone.

Question 12.b: What is the Department's position regarding the use of an acquisition strategy that requires contractors to propose fixed-price production options that are evaluated concurrently with the award of the R&D contract?

Response: The Department's position is that such an approach should only be used in certain limited circumstances when it does not place excessive financial risk on contractors. The circumstances in which this approach may be appropriate include: when the contractor has had an opportunity to build similar hardware in a previous development phase; and when the option quantity is a small portion of the Department's total production requirement.

Question 12.b(1): What guidance has the Department issued to preclude the use of this contracting technique when it will have the effect of awarding a R&D contract on a fixed-price basis in advance of resolution of a program's technical risks?

Response: On April 15, 1991, the Acting Under Secretary of Defense for Acquisition issued a policy letter directing that any proposed use of such options be considered carefully and carried out only when it would not place disproportionate financial risk on contractors.

Question 12.b(2): In the absence of a regulation, should controls be implemented to preclude or govern use of such pricing arrangements?

Response: Controls on this practice already exist. For major defense acquisition programs; the acquisition approach is reviewed by the Under Secretary of Defense for Acquisition and his staff at major milestone points such as the beginning of full-scale development. If that approach provides for the inappropriate use of fixed-price options, that should become apparent during this review. The acquisition approach for non-major programs is similarly reviewed within the services. With the existing guidance on when the use of such fixed-price options is appropriate and when inappropriate, these review mechanisms provide sufficient control to ensure that this practice is not used inappropriately.

13. NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 1990

Please describe the status and actions the Department has taken to implement sections 812 (master agreements for CAAS procurements), section 833 (SDB bond waiver authority), section 834 (company-wide small business subcontract plans) of the National Defense Authorization Act for Fiscal Year 1990.

Response: We published a final DFARS rule on April 15, 1991, implementing section 812 (master agreements for CAAS procurements). We published an interim FAR rule on February 5, 1990, and a final FAR rule on December 21, 1990, implementing section 833 (SDB bond waiver authority). We published a final DFARS rule on July 24, 1990, implementing section 834 (company-wide small business subcontract plans).

14. NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 1991

Please describe the status and actions the Department has taken to implement section 802 (awards without discussions), section 805 (competitive alternative source requirement), section 808 (multiyear contracts), section 832 (minority institution participation in defense research), section 836 (reduction of contract payments for fraud), and section 837 (whistleblower protection) of the National Defense Authorization Act for Fiscal Year 1991.

Response: We issued a departmental letter on March 8, 1991, authorizing all DOD military services and agencies to deviate from FAR and to use DFARS language implementing section 802 (awards without discussions). We have approved a FAR interim rule, for publication in June 1991, to implement this section. Section 805 required no FAR or DFARS implementation, but instead was implemented in DOD Directive 5000.1, Defense Acquisition. We published a final DFARS rule on March 4, 1991, implementing section 808 (multiyear contracts). We have drafted a final DFARS rule implementing section 832 (minority institution participation in defense research) which we plan to publish in September 1991. We have drafted an interim DFARS rule, which will implement a portion of section 836 (reduction of contract payments for fraud). The remainder of section 836 will be implemented in DOD Directive 7050.5, Coordination of Remedies for Fraud and Corruption Related to Procurement Activities. We published an interim DFARS rule on May 29, 1991, implementing section 837 (whistleblower protection).

15. WARRANTIES

Question 15.a: In September 1989 the General Accounting Office (GAO) reported that DOD management controls on the administration of warranties need improvement and recommended that (1) the Secretary establish milestones for the services to meet in implementing effective warranty administration systems and (2) ensure that the services consider the use of waivers when a warranty is not cost-effective. Please describe the actions that the Department has taken to implement these recommendations.

Response: The services have been encouraged to use warranty waivers when the use of a warranty would not be cost-effective nor in the best interest of the government. This is outlined in our warranty policy in the Defense Federal Acquisition Regulation Supplement (DFARS) 246.770-8&9.

Question 15.b: Are there any changes that the Department would suggest to the warranty process?

Response: It is not clear that the law on warranties is necessary.

[Whereupon, at 11:45 a.m., the hearing was adjourned.]

DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993

THURSDAY, APRIL 25, 1991

U.S. SENATE,
SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

NATIONAL CRITICAL TECHNOLOGIES REPORT

The subcommittee met, pursuant to notice, at 9:07 a.m. in room SR-232A, Russell Senate Office Building, Senator Jeff Bingaman (chairman of the subcommittee) presiding.

Committee members present: Senators Bingaman, Nunn, and Coats.

Professional staff members present: David S. Lyles and William H. Smith.

Minority staff members present: Jonathan L. Etherton, professional staff member.

Staff assistants present: Elizabeth Ann Harlow and Camden Jones.

Committee members' assistants present: Edward M. McGaffigan, Jr., assistant to Senator Bingaman; John P. Gerhart, assistant to Senator Bingaman; Leon S. Fuerth, assistant to Senator Gore; Eric H. Thoemmes, assistant to Senator Coats; Ross Lindholm, assistant to Senator Mack; and Thomas L. Lankford, assistant to Senator Smith.

OPENING STATEMENT OF SENATOR JEFF BINGAMAN, CHAIRMAN

Senator BINGAMAN. The hearing will come to order.

This morning the subcommittee meets to receive the first report of the National Critical Technologies Panel. This report was mandated by the Fiscal Year 1990 Defense Authorization Act. According to the provisions in that act, we will receive five more reports on a biannual basis throughout the rest of the decade.

In requesting this report, the subcommittee hoped it would serve as a catalyst for developing a coherent technology policy for the Nation. For that reason, we included representatives from both industry and government on the panel which prepared the report.

We did not expect that the list of technologies identified in the report would differ substantially from the lists in the Department of Defense Critical Technologies Plan, the Department of Commerce emerging technology report, and the various private sector reports, most notably the report that the Council on Competitiveness has recently issued and the report issued by the Aerospace Industries Association. In fact the priority lists that have been issued by the European Community and MITI in Japan are also very similar.

Also, we did not expect substantial controversy about where we stand in these technologies compared to other nations.

We did hope that we could get beyond list-making and comparisons of where we stand to the beginning of an outline of what needs to be done in each of these areas in order to maintain our leadership where we have it, or to catch up where we have fallen behind. And obviously, in reading through the report, in this last and crucial area we are still falling short.

I hope that we can explore in the hearing some of the steps that are being taken to move us ahead in these areas.

In only one of the 22 technologies identified in the report do we have a 5-year action plan, as far as I can determine, which would coordinate among the Federal agencies and do so with strong industry-private sector input. That technology, of course, is in the high performance computing area. We hope that by this time 2 years from now, when the next of these reports is issued, we will have similar action plans for many of the other technologies that have been identified in this report. I believe that efforts are ongoing in FCCSET, the Federal Coordinating Council on Science, Engineering, and Technology, to come up with action plans for the materials and manufacturing technologies. Additional efforts need to be undertaken as soon as possible for other critical technologies, especially those in which we are weak.

The stakes in my view are enormous. We are trying to foster a process that will secure the technological underpinnings of both our national security effort and our future prosperity. As the report correctly points out, technology alone cannot guarantee our security or our prosperity, and that will require innovation and the timely application of technology. But without the technological underpinnings, we clearly would have no chance at all to apply technology to meet our needs as a Nation and maintain our leadership in the world community.

Frankly, it has been startling to me in the 4-plus years that I have been chairman of this subcommittee to find what little has been done in the past to sort out our technological priorities as a Nation. Perhaps that was because the funding for many of these critical technologies is quite modest compared to the advanced tactical fighters or space stations or superconducting supercolliders, and they get much less attention here in Congress and in the administration. My hope is that this report will raise the visibility of these technologies. I fully expect that it will force us to confront the question of what we need to be doing in these key areas where we are falling behind world standards.

We have two excellent witnesses this morning: Dr. William Phillips, who is the Associate Director for Industrial Technology at the Office of Science and Technology Policy. He has had a long and distinguished career in industry and academia, most recently at Washington University in St. Louis.

He and Dr. Allan Bromley, the President's Science Adviser, are trying sincerely to make up for the lack of attention to technology policy through many administrations, both Republican and Democratic. They are having to largely invent processes and institutions as they go, and I do appreciate their efforts even as I push for the earliest possible action in some of these key areas.

Admiral Bob Inman will be speaking this morning in his capacity as Chairman of the Technology Advisory Group to the Council on Competitiveness. Admiral Inman is an extremely respected and frequent witness before the Armed Services Committee, and we are very appreciative of his willingness to be here.

In this most recent capacity as head of this technical, Technology Advisory Group for the Council on Competitiveness, he contributed greatly to the excellent report that was issued by the Council last month entitled "Gaining New Ground; Technology Priorities for America's Future." This report nicely complements the National Critical Technologies Report that is being issued today, since it does make a series of policy recommendations on what needs to be done.

Before we go into the testimony of the witnesses, let me see if Senator Nunn has any statement he would like to make at this time.

Senator NUNN. Mr. Chairman, thank you for your leadership, and also our two witnesses here. I cannot think of anything more important than what you are undertaking in this series of hearings this year. I think that we are going to have to take initiatives.

Admiral Inman has headed part of this group on competitiveness, which I think is essential. I would say to you and to Dr. Phillips, we have great respect for you and we will be carefully studying your testimony.

I am going to have to depart in about 15 minutes. The usual schedule around here: I have something that I have to do. I will be following this issue very closely.

Interestingly enough, Senator Domenici and I are chairing a panel for CSIS on strengthening America, and we are studying your proposals. The one thing we are insisting on is not going back and reinventing the wheel, and we are taking a look at the proposals you have made.

I have talked to Senator Bingaman at length about this issue, and we are both working together on a series of initiatives this year in our defense bill, where appropriate, and in other bills where appropriate. Often, reports are put on the shelf and not paid much attention to. I do not believe that is going to be the case in this instance, and I would encourage you to pass that on to the other members, because we want to talk to you and as we go along I would like to have a chance to visit with both of you.

Thank you.

Senator BINGAMAN. Thank you very much. We appreciate your leadership in this whole series of issues that we are confronting here.

I know Senator Coats will have some comments when he arrives. Why do we not go ahead, Dr. Phillips, and why do you not proceed with your testimony in any fashion you would like, and then we will call on Admiral Inman, followed by questions.

STATEMENT OF WILLIAM D. PHILLIPS, PH.D., ASSOCIATE DIRECTOR FOR INDUSTRIAL TECHNOLOGY, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. PHILLIPS. Mr. Chairman, Senator Nunn, I thank you for giving me the opportunity to present the report of the National Critical Technologies Panel. I am here today in my capacity as chairman of the panel and the views I will express will represent those of the panel.

You have a copy of the report, so I will not repeat much of it in detail. However, I would like to touch on the background, methodology, and philosophy that underlie the final list of critical technologies set forth by the panel. I will also briefly compare the list with those issued by the Department of Defense, Department of Commerce, and the private sector Council on Competitiveness.

The National Critical Technologies Panel was appointed in 1990 in accordance with the Defense Authorization Act for Fiscal Year 1990. Seven of the 13 panel members were from the Federal Government, and the Department of Defense, Department of Energy, Department of Commerce, and National Aeronautics and Space Administration were specified by the act to have representation.

The remaining nine members, three from Government and six from the private sector, were appointed by the Director, Office of Science and Technology Policy.

May I have the first viewgraph, please.

NATIONAL CRITICAL TECHNOLOGIES PANEL (1990-91)

William D. Phillips, Chairman
Associate Director for Industrial Technology
Office of Science and Technology Policy
Executive Office of the President

Frederick M. Bernthal
Deputy Director
National Science Foundation

Charles M. Herzfeld
Director of Defense Research and Engineering
U.S. Department of Defense

Ruth L. Kirschstein
Director
National Institute of General Medical Sciences
National Institutes of Health

Robert W. Lucky
Executive Director of Research
Communication Sciences Division
AT&T Bell Laboratories

Richard C. Messinger
Vice President and Chief Technical Officer
Cincinnati Milacron

Alexander Rich
Sedgewick Professor of Biophysics
Massachusetts Institute of Technolology

Robert Rosen
Deputy Associate Administrator for
Aeronautics, Exploration and Technology
National Aeronautics and Space Administration

Charles V. Shank
Director
Lawrence Berkeley Laboratory

John C. Tuck
Under Secretary
U.S. Department of Energy

Albert R.C. Westwood
Vice President, Research and Technology
Martin Marietta Corporation

Robert M. White
Under Secretary of Technology
U.S. Department of Commerce

James E. Worsham
Chairman
GPA Asia Pacific
(former President, Douglas Aircraft)

I apologize to those in the audience, but there are handouts from the viewgraphs that I will utilize on the table back there.

I will just briefly point out the composition of the panel. As Senator Bingaman indicated, it was truly a private sector-public sector panel, with representation of key players as far as technology, technology deployment, and development were concerned in the Federal Government. People such as Bob Lucky, the Executive Director of R&D at AT&T; Dick Messinger, Cincinnati Milacron, deeply involved in robotics, flexible manufacturing; Alex Rich from MIT, biophysics; and Chuck Shank, Director of Lawrence Berkeley, who also had a distinguished career at AT&T before joining.

So I think we had a truly distinguished panel with wide backgrounds, and I would assure you that the thrust that these panel members brought to this determination was not pure technology, pure science, but, as I will show you a little bit later, the pull was entirely, as these panel members would insist, on the direction of national needs, national security, competitiveness.

In addition to these panel members, we worked very closely with the Department of Agriculture, Department of Transportation, the National Institute of Standards and Technology to ensure that we had a wide perspective.

This diverse representation along with the charge from Congress accounts for the broad range of the panel's list of critical technologies.

We also made a point during the course of the study to talk to and receive briefings from a number of other groups, both in Government and the private sector, who were looking at related issues. I would particularly like to mention the private sector Aerospace Industries Association, the Computer Systems Policy Project, and the private sector Council on Competitiveness, with which we had extremely fruitful interactions.

They were very generous in sharing their knowledge and insight with us. The Council on Competitiveness issued its latest report, as you well know, "Gaining New Ground; Technology Priorities for America's Future," last month. This report contains much in the way of thoughtful analysis and I commend it to you as a document exceedingly well worth reading. We will learn more from these recommendations from Admiral Inman shortly.

The National Critical Technologies Panel approached its task with the benefit of prior Government and private sector studies that I have already mentioned. We quickly realized that determining the level of aggregation at which the critical technologies should be presented was an important consideration.

We could all agree on the general categories, such as materials, manufacturing, biotechnology, so forth. However, these categories were too broad to be useful. On the other hand, focusing on very specific technologies, such as zone refining of silicon or magnetic bearing applications in high speed machining, would have resulted in a list that was much too long and not likely to be comprehensive.

Our choice, then, was to select categories that were more detailed than the major technology areas, but which were groupings of related but more narrowly focused technologies. Thus, for example, Micro- and Nanofabrication represents a family of technologies which include lithography techniques, thin films, surface treatments, and microdevices.

I mention all of this because the panel found no perfect way to deal with the problem of aggregation. In the end it is a matter of judgment, choice, and consensus, and every expert group faced with the same issue will deal with it somewhat differently.

You will see this when you look at the tables in our report that compare the panel's critical technologies with those nominated by other groups. There is general agreement among all of them, taking into account the slightly different objectives and boundary conditions that each group operated under.

Therefore, as a practical matter it is best to concentrate on the overall message of these reports, rather than to get bogged down in the minutia of methodology and taxonomies.

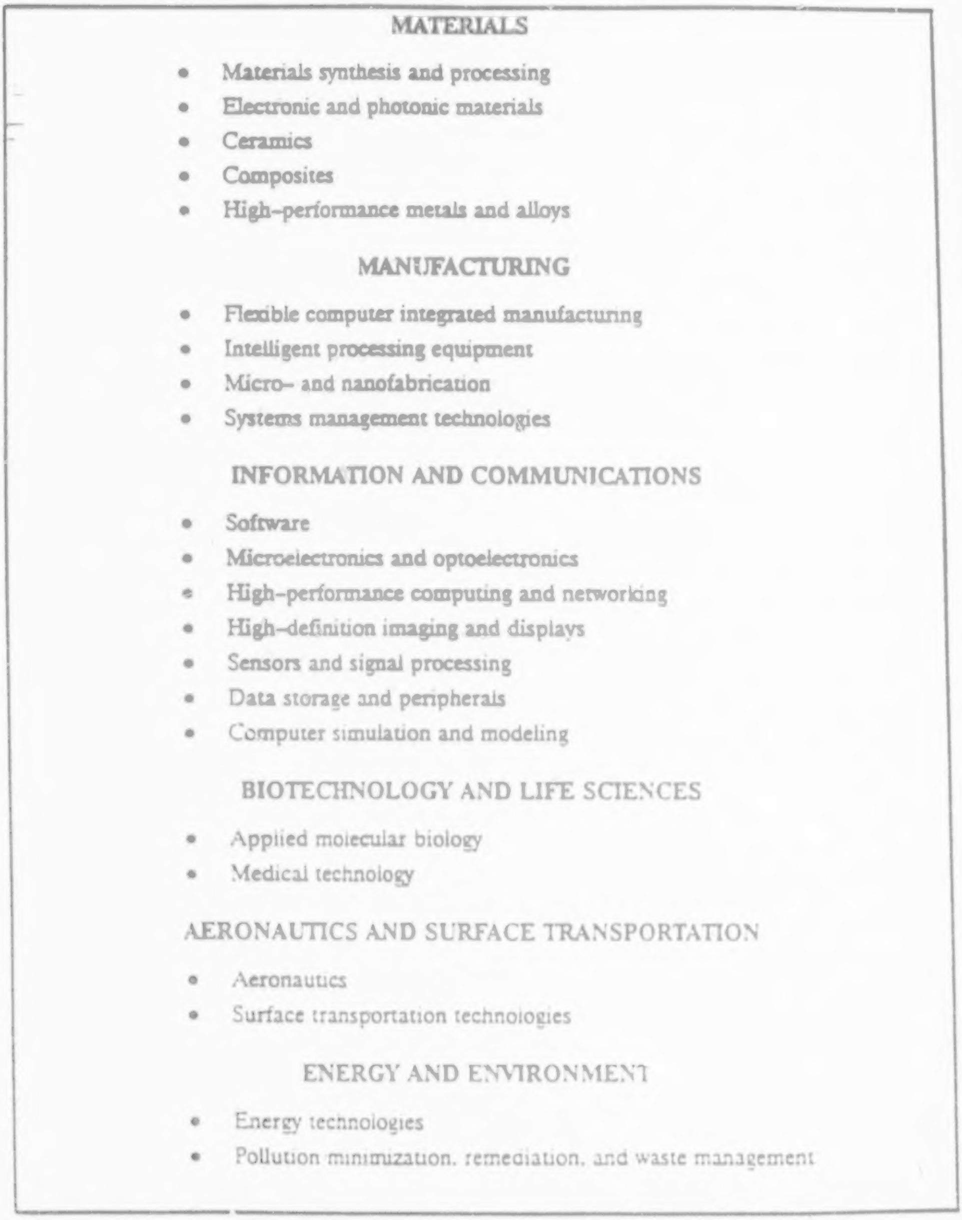
Criteria were very important. We were guided in our final selection by the following considerations: very prominently, national needs, and under national needs I am talking about does it contribute to U.S. competitiveness in world markets? Does it enhance national defense? Does it help our energy security? Does it improve our quality of life?

Under another major criteria category, importance criticality of the technology. Under that, it means does it give us an opportunity to lead the market? Will it lead to improvements in performance, quality, or productivity? Does it provide leverage to stimulate success in other technologies? Will the United States be vulnerable to damage if the technology is held exclusively by another country?

The final set of criteria involved market size. It involved the diversity of the technology, and by that I mean does it form the foundation for many other technologies? Will it exert a major economic impact?

Now, I think you will note in the criteria that we used to guide us that these were not technology push, this was not scientific push. This was truly needs, I mean defined needs, and for these technologies be pulled by the needs. We feel this is a very important thing when one considers technology. It has to be pulled by the needs, and this is what we were careful to try to do. This is what we attempted to do and this is what has been attempted to do in, for example, the other studies, Council on Competitiveness.

NATIONAL CRITICAL TECHNOLOGIES



MATERIALS

- Materials synthesis and processing
- Electronic and photonic materials
- Ceramics
- Composites
- High-performance metals and alloys

MANUFACTURING

- Flexible computer integrated manufacturing
- Intelligent processing equipment
- Micro- and nanofabrication
- Systems management technologies

INFORMATION AND COMMUNICATIONS

- Software
- Microelectronics and optoelectronics
- High-performance computing and networking
- High-definition imaging and displays
- Sensors and signal processing
- Data storage and peripherals
- Computer simulation and modeling

BIOTECHNOLOGY AND LIFE SCIENCES

- Applied molecular biology
- Medical technology

AERONAUTICS AND SURFACE TRANSPORTATION

- Aeronautics
- Surface transportation technologies

ENERGY AND ENVIRONMENT

- Energy technologies
- Pollution minimization, remediation, and waste management

I would like to show you just briefly the viewgraph of the 22 critical technologies, and I am not going to go over these in any detail whatsoever, just pointing out that the critical technologies, the 22, fall into the groupings: materials, manufacturing, information and communications, biotechnology and life sciences, aeronautics and surface transportation, and energy and the environment.

The three at the top, (although we have not made any attempt to order these technologies), the categories under materials, manufacturing, information and communications, are the very central core of what we want in approaching our national needs, whether they be national security, whether they be economic competitiveness, whether they be quality of life in fact. And these are the absolutely core group of technologies from which we cannot afford to have any weaknesses. Otherwise we are exceedingly vulnerable.

Now, one of these I want to discuss just a little bit. One of these very core sets of technologies, namely the materials area, materials provide an excellent example of the interdependencies of the critical technologies and their end uses.

For example, the five materials in materials technology, crucial enabling technologies, for example, the five crucial or very critical materials technologies: materials synthesis and processing. One of the things that we have a tendency to think about are the mundane things, such as synthesis and processing, these are not the spectacular things. However, these are absolutely critical in our quest for quality products, for economy in manufacturing.

These, for example, were very critical areas that the 2-year study of the National Research Council, for example, came up with 2 years ago in materials science and engineering, an extremely crucial area. It is an area which the United States has had a tendency to neglect very badly.

The electronic and photonic materials, ceramics, composites, high-performance metals and alloys, are broken down into subtechnologies. One has to remember that there is no one single technology, there is no one composite, for example, there is no one ceramic. These are a whole series of interrelated technologies.

For each application that you want to make, military application, commercial application, you have to work on a ceramic, for example, that is tailored specifically for that. These are very complex things, but they are absolutely crucial in supporting the rest of our economy, our military, what have you.

For example, if you look at them, of the 17 remaining 22 technologies, 10 are very severely dependent upon these materials categories. For example, micro- and nanofabrication in the manufacturing area, dependent upon materials; microelectronics and optoelectronics, dependent upon materials; high definition imaging and displays, highly dependent upon materials; sensors and signal processing the same; applied molecular biology, this is a materials science unto itself.

Medical technologies: our nuclear magnetic resonance imaging, positron emission tomography, all are very highly dependent upon materials technologies. Aeronautics, the composites, the alloys, the metals that go into it, all are very highly dependent upon materials.

Surface transportation technologies, energy technologies, pollution minimization, remediation, and waste management. This goes all the way through. Our technologies are not independent entities. They are highly interrelated and interdependent.

While I have mentioned materials, I just wanted to add to what Senator Bingaman already has said. With regard to the high performance computing and communications initiative that the administration has put forth, I would like to add that on April 15th the FCCSET, the Federal Coordinating Council on Science, Engineering, and Technology, made the decision to proceed with a major crosscut in the advanced materials and advanced processing area—this top area up here. And that this is a major crosscut under way at this point, which will be the basis for a major initiative in the advanced materials, advanced processing area that will appear in the President's budget for fiscal year 1993.

I would add also, one of our primary categories is biotechnology and life sciences. It was also decided (it was authorized on April 15) that the FCCSET committees would conduct a major crosscut in the biotechnology area as well, and this again will be the basis for a major administration initiative in the biotechnology area for fiscal year 1993.

We are doing preliminary work in the manufacturing area and it may well become a major initiative that will be undertaken next year in preparation for the fiscal year 1994 budget.

One thing that you will note, that the list of technologies does not include technologies that will be realized in the longer term. This includes, for example, nuclear fusion. Nuclear fission is a component of the energy technologies, but nuclear fusion is not, simply because it was considered to be sufficiently far off. Our time horizon was of the order of 10 to 15 years for realization and implementation of the technologies.

We also excluded technologies associated specifically with space exploration, because in our view they had insufficient direct impact on national security and economic prosperity. That is not to say they are unimportant. The panel does recognize, however, that space exploration will continue to stimulate advances in many of the critical technologies.

We included in our panel report a comparison between our critical technologies and those selected by Commerce, Defense, and the private sector Council on Competitiveness. As I mentioned earlier, there is general agreement among them, allowing for differences in criteria, levels of aggregation and definition.

I think the point to be made here is that knowledgeable people, confronted with this task, can generally agree on which technologies are critical. The real challenge we face is not generating a list, but doing something about it.

Also, the considerable overlap between technologies that are critical to both national security and economic prosperity attests to the importance and pervasiveness of these technologies in our lives today.

COMPARISON OF NATIONAL CRITICAL TECHNOLOGIES WITH DEPARTMENT OF COMMERCE EMERGING TECHNOLOGIES AND DEPARTMENT OF DEFENSE CRITICAL TECHNOLOGIES

NATIONAL CRITICAL TECHNOLOGIES	COMMERCE EMERGING TECHNOLOGIES[1]	DEFENSE CRITICAL TECHNOLOGIES[2]
MATERIALS		
• Materials synthesis and processing	• Advanced materials	• Composite materials
• Electronic and photonic materials	• Advanced semiconductor devices • Superconductors	• Semiconductor materials and microelectronic circuits • Superconductors
• Ceramics • Composites • High-performance metals and alloys	Advanced materials	Composite materials
MANUFACTURING		
• Flexible computer integrated manufacturing	• Flexible computer integrated manufacturing	
• Intelligent processing equipment	• Artificial intelligence	• Machine intelligence and robotics
• Micro- and nanofabrication		
• Systems management technologies		
INFORMATION AND COMMUNICATIONS		
• Software	• High-performance computing	• Software producibility
• Microelectronics and optoelectronics	• Advanced semiconductor devices • Optoelectronics	• Semiconductor materials and microelectronic circuits • Photonics
• High-performance computing and networking	• High-performance computing	• Parallel computer architectures
• High-definition imaging and displays	• Digital imaging	• Data fusion
• Sensors and signal processing	• Sensor technology	• Data fusion • Signal processing • Passive sensors • Sensitive radars • Machine intelligence and robotics
• Data storage and peripherals	• High-density data storage	• Photonics
• Computer simulation and modeling	• High-performance computing	• Simulation and modeling • Computational fluid dynamics
BIOTECHNOLOGY AND LIFE SCIENCES		
• Applied molecular biology	• Biotechnology	• Biotechnology materials and processes
• Medical technology	• Medical devices and diagnostics	
AERONAUTICS AND SURFACE TRANSPORTATION		
• Aeronautics		• Air-breathing propulsion
• Surface transportation technologies		
ENERGY AND ENVIRONMENT		
• Energy technologies		
• Pollution minimization, remediation, and waste management		
		• No National Critical Technologies counterpart: High energy density materials, Hypervelocity projectiles, Pulsed power, Signature control, Weapon system environment.

[1] U.S. Department of Commerce, *Emerging Technologies: A Survey of Technical and Economic Opportunities*, Spring 1990.
[2] U.S. Department of Defense, *Critical Technologies Plan*, 15 March 1990.

Again, as you already pointed out, Senator Bingaman, there is a great deal of correspondence between the technologies, for example, that were identified by the National Critical Technologies Panel, shown on the left, the Department of Commerce emerging technologies that were published in May of last year, and the Defense critical technologies. The last one of DOD to be published was in March of last year and there will be another one shortly coming up.

Again, I will not show in detail, but again taking into consideration the differences in the sets of criteria, there is a remarkable concurrence in identified technologies. There are only five of the critical technologies on the Department of Defense list that do not occur on the national critical technologies list.

These are—as you might expect, certain critical technologies that are unique to the defense needs. This is to be expected, but it is a rather small number.

Now, the next viewgraph shows a comparison with the very extensive determination by the Council on Competitiveness. Again, there is an excellent, really quite remarkable correspondence between the lists identified by the Council on Competitiveness and ourselves.

COMPARISON

NATIONAL CRITICAL TECHNOLOGIES PANEL	COUNCIL ON COMPETITIVENESS CRITICAL TECHNOLOGIES
MATERIALS	
· Materials synthesis and processing	· Materials processing
· Electronic and photonic materials	· Electronic and photonic materials
· Ceramics	·
· Composites	· Advanced structural materials
· High-performance metals and alloys	·
MANUFACTURING	
· Flexible computer-integrated manufacturing	· Design and engineering tools
· Intelligent processing equipment	· Commercialization and production systems
	· Process equipment
· Micro- and nanofabrication	· Microelectronics
· Systems management technologies	· Commercialization and production systems
INFORMATION AND COMMUNICATIONS	
· Software	· Software
· Microelectronics and optoelectronics	· Microelectronics
	· Optoelectronic components
	· Electronic packaging and interconnections
· High-performance computing	· Computers and networking
	· Networks and communications
—	· Portable telecommunications equipment and systems
· High-definition imaging and displays	· Displays
· Sensors and signal processing	· Electronic controls
	· Human interface and visualization technologies
· Data storage and peripherals	· Information storage
	· Hardcopy technology
	· Database systems
· Computer simulation and modeling	· Software
BIOTECHNOLOGY AND LIFE SCIENCES	
· Applied molecular biology	· Biotechnology
· Medical technology	—
AERONAUTICS AND SURFACE TRANSPORTATION	
· Aeronautics	· Propulsion
· Surface transportation technologies	· Powertrains
ENERGY AND ENVIRONMENT	
· Energy technologies	· Powertrains
· Pollution minimization, remediation, and waste management	· Environmental technologies

What this of course is telling us is that a consensus has been arrived at. In addition, these technologies are closely related to critical technologies that have been arrived at by the European Community groups, and the Japanese groups. There is a general, worldwide consensus on the really important critical technologies.

Just a few more remarks. The Critical Technologies Panel believes that the U.S. science base is unmatched in the world today. Science is the wellspring from which all technology is derived and our broad scientific base allows us to generate technology in abundance. That is not our problem.

Support for the basic sciences needs to be broadly based in order to maximize the yield of advances. That is, there is a real difference between science and technology. We absolutely must continue the broad-based support for science that we presently have.

In contrast, technology development and deployment, because of the time and resource commitments involved, require much greater selectivity and concentration of resources than is appropriate for the basic sciences. This is why we need to go through these exercises of determining critical technologies.

However, in an environment of intensifying global competition it is not enough to come up with new ideas or even to develop these ideas into new technologies. The ultimate payoff comes when technologies are deployed, whether for military or commercial purposes.

In the commercial world, successful firms are not necessarily discoverers and developers of the latest innovation, but those that are able to swiftly bring the associated products to market. Those firms must also maximize profits in order to sustain through reinvestment a continuing flow of both new and improved products derived from research and development.

Therefore, it is not the identification of critical technologies, nor even the development of those technologies, that is important. It is what you do with them that matters.

With that in mind, the panel has placed greatest emphasis on technologies that relate to new products and on the processes that make them. It is essential in today's environment to take an integrated approach to manufacturing process and product design, performance, quality, and cost. This integrated approach applies both to defense and commercial sectors of the economy.

Finally, the panel recognizes the importance of science and mathematics education to the Nation's ability to remain a world leader in technology and technology application. Our ability to reap the benefits of the national critical technologies will depend on the generation of a technically literate workforce that possesses the skills to develop and master these and future technologies.

Where do we go from here? As I have emphasized, our focus should not be on continuing to generate new lists which all say about the same thing, but on doing something to improve the U.S. position. The panel did not address implementation, but the Critical Technology Institute which is in the process of being established under the Fiscal Year 1991 Defense Authorization Act will be concerned primarily with follow-up on the panel's report.

We need to have a better understanding of overseas models in order to assess the nature of the competition. The value of research and development consortia need to be assessed, and the role of Federal laboratories needs to be examined. We also need to examine regulatory barriers, the limited available pool of capital, and other inhibiting factors that may be affecting our ability to compete internationally.

I would point out that the Vice President's Council on Competitiveness has looked into these issues and released just yesterday a study on policies in support of technology development in the United States. This release should be over here shortly, and there will be copies available to those who would be interested in it.

In conclusion, I believe that the primary benefit of doing this study has been to emphasize not only the importance of certain technologies, but to highlight the fact that technology alone cannot assure economic prosperity and national security. It can make an important contribution, but only if we learn to use it more effectively in developing innovative, high-quality, cost-competitive products and bringing these products to market in a timely manner. To do so will require, above all, continuing evolution in our approach to international economic competition.

Thank you, Mr. Chairman. I appreciate this opportunity. I will be happy at the appropriate time to answer questions.

[The prepared statement of Dr. Phillips follows:

PREPARED STATEMENT BY WILLIAM D. PHILLIPS, CHAIRMAN, NATIONAL CRITICAL TECHNOLOGIES PANEL

Mr. Chairman: Thank you for giving me the opportunity to present the report of the National Critical Technologies Panel. I am here today in my capacity as Chairman of the Panel, and the views I will express represent those of the Panel. You have a copy of the report, so I will not repeat much of the detail in it. However, I would like to expand a little on the background, methodology, and philosophy that underlie the final list of critical technologies set forth by the Panel. I will also briefly compare the list with those issued by the Department of Defense, Department of Commerce, and private sector Council on Competitiveness.

NATIONAL CRITICAL TECHNOLOGIES PANEL

The National Critical Technologies Panel was appointed in 1990 in accordance with the Defense Authorization Act for Fiscal Year 1990. Seven of the 13 Panel members were from the Federal Government, and the Department of Defense, Department of Energy, Department of Commerce, and National Aeronautics and Space Administration were specified by the Act to have representation. The remaining nine members, three from government and six from the private sector, were appointed by the Director, Office of Science and Technology Policy (OSTP).

In appointing these nine members, OSTP tried to achieve a wide representation of expertise and experience, bearing in mind that the study was focused on technologies "essential for the long-term national security and economic prosperity of the United States." We were fortunate to have the private sector represented by Dr. Robert W. Lucky, an expert in electronics, information, and communications from AT&T Bell Laboratories; Dr. Richard C. Messinger from Cincinnati Milacron, an expert in manufacturing and machine tools; Dr. Alexander Rich, renowned researcher in molecular biology and professor of biophysics at M.I.T.; Dr. Charles V. Shank, Director of the Department of Energy's Lawrence Berkeley Laboratory and an expert in optics and electronics; Dr. Albert R.C. Westwood, Vice President for Research and Technology at Martin Marietta Company, one of the major U.S. aerospace corporations; and Mr. James Worsham, former President of Douglas Aircraft with wide experience in aviation and aircraft manufacturing. These Panel members brought with them invaluable knowledge, not just about technologies but also about broader issues of commercialization and competition in the international marketplace.

In addition, we were ably assisted by Panel members representing the National Science Foundation and National Institutes of Health. Although the specified size of the Panel precluded appointing experts in other fields of technology, we worked very closely with the Department of Agriculture, Department of Transportation and the National Institute cf Standards and Technology to ensure that we had a wide perspective. This diverse representation, along with the charge from Congress, accounts for broader range of the Panel's list of critical technologies than is seen in the Department of Commerce's list of emerging technologies or the Defense critical technologies.

We also made a point during the course of the study to talk to and receive briefings from a number of other groups, both in government and the private sector, who were looking at related issues. I would particularly like to mention the private sector Aerospace Industries Association, the Computer Systems Policy Project, and the Council on Competitiveness with which we had fruitful interactions. They were very generous in sharing their knowledge and insight with us. The Council on Competitiveness issued its latest report "Gaining New Ground: Technology Priorities for America's Future" last month. The report contains much in the way of thoughtful analysis, and I commend it to you as a document well worth reading.

METHODOLOGY

The National Critical Technologies Panel approached its task with the benefit of prior government studies that I have already mentioned: The Defense Critical Technologies Plan (issued annually beginning in 1989), and the Commerce Emerging Technologies report issued in 1990. We quickly realized that determining the level of aggregation at which the critical technologies should be presented was an important consideration. We could all agree on the general categories such as materials, manufacturing, biotechnology, and so forth. However, these categories were too broad to be useful. On the other hand, focusing on very specific technologies such as zone refining of silicon or magnetic bearing applications in high-speed machining would have resulted in a list that was much too long and not likely to be comprehensive. Our choice, then, was to select categories that were more detailed than the major technology areas but which were groupings of related but more narrowly focused technologies. Thus, for example, Micro- and Nanofabrication represents a family of technologies which include lithography techniques, thin films, surface treatments, and microdevices. In a few cases, as in High-Performance Metals and Alloys, the Panel added subtitles (shown in parentheses) to delineate the technologies of interest within a very broad category.

I mention all this because the Panel found no perfect way to deal with the problem of aggregation. In the end it is a matter of judgment, choice, and consensus; and every expert group faced with the same issue will deal with it somewhat differently. You will see this when you look at the tables in our report that compare the Panel's critical technologies with those nominated by other groups. There is general agreement among all of them, taking into account the slightly different objectives and boundary conditions that each group operated with. Therefore, as a practical matter it is best to concentrate on the overall message of these reports rather than get bogged down in the minutiae of methodology and taxonomies.

We were guided in our final selection by the following considerations:

National needs

— Does it contribute to U.S. competitiveness in world markets?
— Does it enhance national defense?
— Does it help our energy security?
— Does it improve our quality of life?

Importance/Criticality

— Does it give us an opportunity to lead the market?
— Will it lead to improvements in performance, quality, or productivity?
— Does it provide leverage to stimulate success in other technologies?
— Will the United States be vulnerable to damage if the technology is held exclusively by another country?

Market Size/Diversity

— Does it form the foundation for ma~~ny oth~~er technologies?
— Will it exert a major economic impact?

I realize that there are varying degrees of overlap among these criteria, but they were employed as guides, not as absolute figures of merit. As has been the case in related studies, the Panel was able to agree on a final compilation of technologies without necessarily agreeing completely on definitions or on the relative importance of various criteria.

CRITICAL TECHNOLOGIES

The final list of 22 critical technologies selected by the National Critical Technologies Panel is:

MATERIALS

- Materials synthesis and processing
- Electronic and photonic materials
- Ceramics
- Composites
- High-performance metals and alloys

MANUFACTERING

- Flexible computer integrated manufacturing
- Intelligent processing equipment
- Micro- and nanofabrication
- Systems management technologies

INFORMATION AND COMMUNICATIONS

- Software
- Microelectronics and optoelectronics
- High-performance computing and networking
- High-definition imaging and displays
- Sensors and signal processing
- Data storage and peripherals
- Computer simulation and modeling

BIOTECHNOLOGY AND LIFE SCIENCES

- Applied molecular biology
- Medical technology

AERONAUTICS AND SURFACE TRANSPORTATION

- Aeronautics
- Surface transportation technologies

ENERGY AND ENVIRONMENT

- Energy technologies
- Pollution minimization, remediation, and waste management

The order in which the technologies are listed does not reflect a prioritization. In fact, the interesting feature of technologies today is that they are all interrelated. For example, continuing advances in computer software are necessary to support development of advanced capabilities in simulation and modeling, high-performance computing, and intelligent processing equipment. The only distinction on the list is between the first three general categories, Materials, Manufacturing, and Information and Communications, and the last three. The first three can be considered as "building blocks" for virtually all sectors of the economy. The other three categories are more akin to major areas of applications. However, all 22 technologies are critical to future U.S. national security and/or economic well-being.

You will note that the Panel did not include technologies that will only be realized in the longer term, such as nuclear fusion. We also excluded technologies associated specifically with space exploration because they had insufficient direct impact on national security and economic prosperity. The Panel did recognize, however, that space exploration will continue to stimulate advances in many of the critical technologies.

We included in our Panel's report a comparison between our critical technologies and those selected by Commerce, Defense, and the Council on Competitiveness. As I mentioned earlier, there is general agreement among them, allowing for slight differences in criteria, levels of aggregation, and definitions. I think the point to be made here is that knowledgeable people confronted with this task can generally agree on which technologies are critical. The real challenge we face is not generating a list but doing something about it. Also, the considerable overlap between technologies that are critical to both national security and economic prosperity attest to the importance and pervasiveness of these technologies in our lives today.

IMPLICATIONS

The key point that the Panel wants to emphasize is that technology alone cannot ensure national security and economic prosperity. Technology can make an important contribution to the future of U.S. national interests, but only if we learn to utilize it more effectively.

The Panel believes that the U.S. science base is unmatched in the world today. Science is the wellspring from which all technology is derived, and our broad scientific base allows us to generate technology in abundance. Support for the basic sciences needs to be broadly based in order to maximize the yield of useful advances. In contrast, technology development and deployment, because of the time and resource commitments involved, require greater selectivity and concentration of resources than is appropriate for the basic sciences.

However, in an environment of intensifying global competition, it is not enough to come up with new ideas, or even to develop those ideas into new technologies. The ultimate payoff comes when technologies are deployed, whether for military or commercial purposes. In the commercial world, successful firms are not necessarily the discoverers and developers of the latest innovation, but those that are able to swiftly bring the associated products to market. Those firms must also maximize profits in order to sustain through reinvestment a continuing flow of both new and improved products derived from research and development. Therefore, it is not the identification of critical technologies nor even the development of those technologies that is important; it is what we do with them that matters.

Future U.S. competitive success requires a fundamental change in the way U.S. industry competes in the marketplace. Our research institutions and businesses must place greater emphasis on deployment of new technologies. Furthermore, discovery, development, and deployment must be integrated and viewed as concurrent rather than sequential activities. As one of our Panel members expressed it: "U.S. industry must be infused, from the boardroom to the factory floor, with a relentless desire to constantly improve both product and production methods."

With that in mind, the Panel placed special emphasis on technologies related to the creation of new products and on the processes to make them. It is essential in today's competitive environment to take an integrated approach to manufacturing process and product design, performance, quality and cost. This integrated approach applies both to defense as well as commercial sectors of the economy.

Finally, the Panel recognized the importance of science and mathematics education to the Nation's ability to remain a world leader in technology and technology application. Our ability to reap the benefits of the National Critical Technologies will depend on the generation of a technically literate workforce that possesses the skills necessary to develop and master these and future technologies.

Where do we go from here? As I have emphasized, our focus should not be on continuing to generate new lists, which all say about the same thing, but on doing something to improve the U.S. position. The Panel did not address implementation, but the Critical Technology Institute which is in the process of being established under the Fiscal Year 1991 Defense Authorization Act will be concerned primarily with follow-up on the Panel's report. We need to have a better understanding of overseas models in order to assess the nature of the competition. The value of research and development consortiums needs to be assessed, and the role of Federal laboratories should be examined. We also need to examine regulatory barriers, the limited available pool of capital, and other inhibiting factors that may be affecting our ability to compete internationally.

In conclusion, I believe that the primary benefit of doing this study has been to emphasize not only the importance of certain technologies but to highlight the fact that technology alone cannot ensure economic prosperity and national security. It can make an important contribution, but only if we learn to use it more effectively in developing innovative, high-quality, cost-competitive products and bringing those products to market in a timely manner. To do so will require, above all, continuing evolution in our approach to international economic competition.

Senator **Bingaman**. Thank you very much, Dr. Phillips.

Before you begin your testimony, Admiral Inman, I have been advised that some of our members will be attending the memorial service that has been scheduled this morning for former Senator Tower. Out of respect for Senator Tower, following your statement, we will recess until about 10:15.

How long do you expect your initial statement to take?

Admiral **Inman**. I will do it in about 10 minutes.

Senator **Bingaman**. That will be terrific. We will proceed on that basis, and then we will recess after that statement until about

10:15 at which time we will begin with questions. Admiral Inman, why do you not go ahead.

STATEMENT OF ADMIRAL BOBBY R. INMAN, U.S. NAVY RETIRED, CHAIRMAN OF THE EXECUTIVE COMMITTEE, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Admiral INMAN. Thank you, Mr. Chairman. I appreciate the opportunity to appear before the subcommittee of the Senate Armed Services Committee today.

I have out in the private sector and in the academic community had some questions raised of why is the Senate Armed Services Committee pursuing this topic? Why is this the principal arena for review of a report done by an industry group called "Gaining New Ground"?

I am very comfortable in the role that needs to be played and I am going to spend a brief minute on it. If I may, I have a statement, prepared with the great help of David Cheney from the Council on Competitiveness, who is with me, that I will submit for the record.

Senator BINGAMAN. We will be glad to include that full statement.

Admiral INMAN. But I want to do particularly the first paragraph, to set the stage.

> "In recent years the relationship between civilian and defense technology has fundamentally changed. For most of the period after World War Two, defense technologies were more advanced than civilian technology and many benefits flowed from defense R&D to civilian technologies.
>
> "Today many civilian technologies are more advanced than defense technologies. It is no longer possible to maintain leadership in defense technologies by defense R&D alone. A strong civilian or dual use technology base is essential to leadership in the defense technologies."

It is therefore appropriate in my view for the committee to examine U.S. performance in technologies that underlie the civilian as well as the defense industrial base.

Over the weekend across my desk in Austin passed a report that I want to specifically call attention to this morning, called "Integrating Commercial and Military Technologies for National Strength; an Agenda for Change." It is a report of the Steering Committee on Security and Technology. I note the three co-chairs were Jeff Bingaman, Jacques Gansler, and Robert Kupperman.

Mr. Chairman, I would bring it up if Phil Gramm were the cochair and not Jeff Bingaman, because I think you got the issues right. The specific paragraph that I want to call broad attention to in the conclusion and recommendations:

> "The Steering Committee on Security and Technology believes that with the declining defense budget the United States is at a turning point in defense procurement. One choice is to stay with what we have, a procurement system that emphasizes fairness, oversight, and unique weapons performance, but yields overly expensive systems and a limited and highly specialized defense industrial base.
>
> "The alternative is to adopt a dramatically different procurement strategy, one that places higher priority on efficiency, system effectiveness, and industrial responsiveness, with linkage to a broad commercial infrastructure where possible.
>
> "Both options have worthy goals and each imposes a different set of penalties. Unfortunately, as the case studies highlight, the benefits tend to be mutually incompatible. There is no way to combine the best of both. A choice must be made."

I hope this report gets very widely read and circulated, not only in the policy community but also here on the Hill, where I am persuaded that for 20 years those who are labeled military reformers have worked with the very best of intentions and have helped produce the results we have today, and that there is a critical need to address change.

A fundamental part of that change is aiming at how do we create ultimately a national technology data base that supports all the needs of the country. It is easy to talk about it. It will be very hard to actually define it and implement it.

Its role I think fits in a broader look at how this country succeeds in an international marketplace. We must have readily available capital at competitive rates. We must have a skilled and motivated work force. We must have a strong base of science and technology and the infrastructure that supports it.

We must have a clear, unremitting focus on quality, innovation, productivity, safety, both safety of individuals and safety of the environment, and on protection of intellectual property.

The first three of those—the cost of capital and its readily available supply; the skilled and motivated work force; and the strong base of science and technology—require leadership from the Government and strong industry participation. Quality, innovation, productivity, safety require strong leadership from industry with support from Government. But a partnership in attacking all these issues, rather than an adversarial relationship, is absolutely critical.

I consider this hearing an important step in that process of building the relationships and to try to understand where we ought to go.

In fairness to the extremely talented group of men and women from industry who participated in the development of the report "Gaining New Ground," I must note that on every occasion that we met, even though technology was our focus, we came back to education as a critical issue. Not a single session passed where that did not come back as a problem that we have to solve.

In putting together the report, we kept policy issues off the table until we could get an agreement on what were the critical technologies, what were the lessons to be learned, and then we turned to policy recommendations. I am particularly proud that this report does not just recommend what Government needs to do, but it does include some challenges for industry and for the academic community.

On some occasions, we soft-pedaled the strength of criticism that would have come from the panel where I did not believe that we had done the research that would support the strength of criticism. First and foremost was in the approach to investment by the Federal Government in our national laboratories—Government owned and operated, Government owned and contractor operated, Federally funded research and development centers.

We do not say much about them in the report because I could not develop a consensus among the members on what to do. But there is a very substantial unease that these great institutions have grown, they have a substantial investment in infrastructure, and a lot of talented people. The issue is whether the level of investment is merited by the output and how it impacts on the broad range of technology issues.

I hate to come out from a committee recommending another study, but I think it is an area that needs very careful examination going forward, to say what is the balance in investment, are there ways we can make far better use of the national laboratory infrastructure that we have?

The report contains its own list of recommendations for critical technologies, but I believe one of its most important parts is in trying to assess why we are strong in some areas and why we are weak or losing badly in others. The points I would call to your attention for this discussion—and we should not underestimate our strengths. In some areas, like software, we are doing extraordinarily well.

We tend to be strongest where the product is close to basic research. We do very well where innovation is a key factor. We do very well where there is low capital requirement. Again software stands out. In being close to basic research, biotechnology stands at the top of the list.

We are strong in technologies where industry has always invested heavily in technology. There are not very many of those, but chemicals and pharmaceuticals stood out as two areas that were particularly strong. There has been matching investment in information technologies, paralleling that. There is also a pattern in some of the areas of strong Government support: R&D investment, biotechnologies; procurement policy, rocket propulsion; or sometimes from regulation, the lead we have in emission controls on the rest of the world.

We tend to be weakest where there is a large separation between basic research and the actual commercial product, where extensive investment for a long period of time is necessary before you get a result, where a large investment of capital is needed and there is relatively little capital investment in the industry, particularly machine tools, in areas where we have simply not focused on the critical role of manufacturing processes design as the critical element in accelerating time to market.

On the policy front, you will have seen the long list of recommendations: that we do need to set out detailed plans over 5 years for investment in technologies; that the President needs to lead the effort, beginning by declaring our striving for technology preeminence as a national goal across the board.

We need, both at the Federal and State level, to substantially increase investment in infrastructure. On the industry side, not only do we need to have a much better sharing of risk and sharing of information in the pre-competitive stage, but we also need to have an absolute commitment to excellence across the board, best commercial practice to be found anywhere in the world as a goal across the board.

You have heard me before. As I look back over my 30 years of public service, I have wonderful memories, but one phrase that stands out that can still cause the hair to stand up on the back of my neck, that is "close enough for government work." I think it sets a tone that demeans performance, but also leads to poorer performance.

Unfortunately, I find too often in industry a comparable approach: What is good enough to make a profit, as opposed to what is the very best performance that we can achieve against all competitors.

Finally, watching the clock, we had particular concern in this task force that we not erode one of the country's major competitive advantages, that is the breadth and depth of research conducted in American universities. No other country in the world has a resource that compares to it, and I worry as I watch the ongoing examination of both real and perhaps some not so real abuses in overhead costs that we may end up if we are not careful creating a massive new bureaucracy that will do as much damage to that valuable research as I believe has been done over time to defense procurement.

But even as we want to protect that university research, there was a very strong view in this task force that American education institutions need to do more in pushing the technology they are helping to create out for earliest use and focusing on how they could help accelerate the technology transfer processes, how their own programs, the curricula that they develop, help us get on with tackling the problems where we are furthest behind: process engineering, the design, the integration of research and manufacture for new products, and substantially collapsing the time to market that we now have.

There are a lot of challenges for the university community as well as the private sector and Government.

Thank you very much, Mr. Chairman.

[The prepared statement of Admiral Inman follows:

Prepared Statement by Adm. B.R. Inman, U.S. Navy (Ret.), Chairman, Technology Advisory Committee, and Member, Executive Committee, Council on Competitiveness

In recent years the relationship between civilian and defense technology has fundamentally changed. For most of the period after World War II, defense technologies were more advanced than civilian technology and many benefits flowed from defense R&D to civilian technologies. Today, many civilian technologies are more advanced than defense technologies. It is no longer possible to maintain leadership in defense technologies by defense R&D alone. A strong civilian, or dual-use, technology base is essential to leadership in defense technologies.

It is, therefore, especially appropriate that your committee examines the U.S. performance in the technologies that underlie the civilian—as well as defense—industrial base.

Today I am testifying on the New Council on Competitiveness Report, *Gaining New Ground: Technology Priorities for America's Future*. The Council on Competitiveness is a non-profit, nonpartisan organization of chief executives from business, higher education, and organized labor who have joined together to improve the ability of American companies and workers to compete in world markets while raising living standards at home. The report represents a remarkable consensus among America's corporate, labor and academic leaders on the critical technologies essential for industry's competitive performance in the next decade. It provides a plan for what industry government and academe need to do to gain ground in the competition for leadership in these technologies.

The Council began this study because it was apparent to us that America was losing its leadership in what has always been our strong suit—technology. It was also clear to us that industry bore a large part of the responsibility for this loss; it is ultimately industry's responsibility to develop technologies and bring them to the market. Yet industry had not done its share in determining how to reverse these trends.

When government did hear from industry, it was usually from an industry that was suffering from international competition. Their requests were often seen as special pleading.

Therefore, we designed a project to develop a broad-based industry consensus on what needs to be done to promote U.S. leadership in technology. It was not designed to favor any particular industry, but was designed to support all U.S. industries, and, in fact, America's economic future.

We convened an advisory committee of the best technology people in industry. These are people who understand the technologies that their industries need, and understand the relationship between technology and their industry's business.

We did detailed studies of nine diverse sectors of U.S. industry. These included high technology industries, such as computers, and more traditional industries, such as construction. They included manufacturing industries, such as automobiles, and service industries, such as telecommunications.

We identified which technologies were critical to each industry over the next decade and we assessed how we are doing in each technology. And we assessed the factors that determine how we are doing in each technology.

We kept policy issues off the table until we had completed our study of the industries and the technologies. We then compiled the findings and the policy recommendations based on a synthesis of the knowledge from each sector.

I will briefly go through the Council's findings and a few of the recommendations in the report.

KEY FINDINGS

The report contains six key findings.

First, there is a broad domestic and international consensus about the critical generic technologies driving economic growth and competitiveness. The technologies that we found to be critical to a broad cross-section of U.S. industry are largely the same as those already identified by the Department of Defense, the Department of Commerce, and now, the Office of Science and Technology Policy. It is also largely the same as the technologies identified by the Japanese Ministry of International Trade and Industry, and the Commission of the European Communities.

Second, the U.S. position in many critical technologies is slipping and, in some cases, has been lost altogether. Future trends are not encouraging. A decade ago we would have had a very strong position in virtually every part of the Nation's technology base. Now we are no longer competitive in a disturbing number of critical technologies.

Third, foreign governments are systematically pursuing leadership in critical technologies.

Fourth, U.S. public policy does not adequately support American leadership in critical technologies, and U.S. national priorities do not sufficiently address issues related to the role of technology in U.S. competitiveness.

Fifth, most of the technologies that will drive economic growth over the next decade already exist, and industry needs to improve its ability to convert them into marketable products and services.

And sixth, America's research universities constitute a great national asset, but their focus on technology and competitiveness is limited.

The Council found that advances in materials, engineering and production technologies, electronic components, and information technologies are driving improvements in products and processes in all industries. Powertrain and propulsion technologies are also critical due to their great economic importance.

We found that we are generally strong in information technologies like software and systems-integration, strong or competitive in materials and processing, and weak in electronic components and engineering and production technologies. The pattern of where we are strong and where we are weak tells us important things about what we as a nation are doing well and what we are doing poorly.

We are strong in the technologies where basic research—which is the great U.S. strength—can relatively quickly be converted into commercial technologies. An example is biotechnology.

Similarly, we tend to be strong in technologies that do not require heavy capital investment, such as software. In these technologies entrepreneurs can successfully start up new companies and get new ideas to the market.

We are strong in technologies where industry has always invested heavily in technology, such as pharmaceuticals and chemicals.

We are also strong in technologies that are supported by various national priorities. We are strong in environmental technologies because of strong environmental regulations and are strong in propulsion technologies and some advanced materials because of defense procurement.

Our strengths should not be underestimated. Our strength in software is critical. In the Persian Gulf war, it was often the software rather than the hardware that made the decisive difference in the effectiveness of weapons.

We tend to be weak in areas, such as electronic components, where there is a large separation between basic research and commercial product development and where there is a long capital-intensive technology development stage.

We are weak in many areas of manufacturing technology, and consequently, in many technologies where skill in manufacturing is a key to success.

And finally, we are weak in many areas that have been targeted by foreign governments.

One cause of weakness is a lack of cooperation among U.S. industry in technology development. Companies in other countries have cooperated more effectively to share technology and risk than have U.S. companies.

These patterns of weakness point out serious shortcomings in the U.S. system of promoting technology. Since World War II, the country has recognized that support of basic research is critical to a dynamic economy, and that left to itself, industry will not fund adequate amounts of basic research.

In some technologies, such as biotechnologies, basic research is all the precompetitive technology that industry needs. But in other technologies, including many manufacturing and electronic component technologies, there is a large gap between where basic research stops and where proprietary technology development begins. Defense and space funding once provided this applied R&D. But as the contribution of defense R&D to civilian technology has declined, defense R&D is no longer adequate. The U.S. Government has not yet significantly supported precompetitive R&D on generic technologies, and neither has industry.

Our recommendations to solve these problems are based on the premise that U.S. industry has the primary role in developing and achieving success in commercial technologies. Government and universities have supporting roles. Government has a critical role in supporting precompetitive research and in creating the economic and regulatory environment that encourages investment in technology. The role of universities is to provide people with education that meets the needs of industry and to conduct some of the fundamental research that industry needs.

Much can be done without significant new Federal funding. New priorities for Federal R&D can make a major contribution to maintaining our technological base. The U.S. Government and the private sector must work together to ensure leadership in the development, use and commercialization of technology.

Our recommendations respond to and build on the policies outlined in the President's U.S. Technology Policy, released by the White House in September of last year. We have five main recommendations—two for the government, two for industry, and one for universities.

First, the President should act immediately to make technological leadership a national priority. This recommendation has several elements. One element is to develop a 5-year implementation plan to support R&D on critical generic technologies. OSTP and the Critical Technologies Institute should work with industry to set priorities in critical generic technologies, translate these priorities into specific actions plans, and implement these plans.

We strongly support OSTP's activities. Their technology list includes the technologies that are essential for industry. The Critical Technologies Institute can make the transition from lists of technologies to programs that support technologies. We are committed to supporting them and working with them as they move forward.

The key agencies that fund precompetitive generic R&D, including the National Institute of Standards and Technology, the National Institutes of Health, the National Science Foundation, and the Defense Advanced Research Projects Agency, should be strengthened.

We believe that DARPA has a legitimate role in supporting dual-use technologies, and should also support manufacturing R&D.

The Federal laboratories' contribution to U.S. competitiveness must be made commensurate with the national investment in them. We believe that the Federal laboratories and the scientists and engineers that work there are an important national resource, but that they are, at present, providing little benefit to commercial technologies. To make them contribute more will require a cultural change, and a fundamental change in their relationship with industry.

Our second main recommendation is that Federal and State governments should strengthen the infrastructure for technology development. This infrastructure consists of physical assets such as equipment, facilities and networks, and human capital, such as skilled scientists, engineers and other personnel.

The Federal Government should assess the Nation's technology infrastructure needs, benchmark what foreign governments are doing, and develop strategies, programs and implementation plans to make sure that the United States has a world-class infrastructure. The administration's high performance computing and networking initiative is a positive example.

Our second set of recommendations are to industry. U.S. industry can do much to help itself in technology development.

U.S. industry should establish more effective technology networks to help it compete in the international marketplace. Industry organizations can promote sharing of precompetitive information on technology and technology management practices, and can develop plans and programs to develop critical generic technologies.

Individual firms should strive to meet and surpass the best commercialization practices of their competitors. They should match the President's goal to increase dramatically the percentage of R&D expenditures that support critical generic technologies.

Finally, universities, while keeping their basic research programs strong, should develop closer ties to industry so that education and research programs contribute more effectively to the real technology needs of the manufacturing and service sectors.

These recommendations are described in detail in the report.

It is important to note that these recommendations are not the complete solution to our technology problems or competitiveness problems. Although we deliberately did not address education in this study, the need for a skilled and motivated work force came up at every advisory committee meeting. And although we did not address macroeconomic issues, the ability of U.S. industry to make long-term investments is critical to our performance in technology. The Council has another major study underway—on the time horizons of American management—that will address these issues in detail.

But the recommendations presented here will make a difference. The Council has committed itself to working toward their implementation.

In conclusion, the renewal of American technological leadership does not require major new government programs or funding. It does requires a new sense of priority and partnership among industry, government, labor, and universities.

I will be happy to answer your questions.

Senator BINGAMAN. Thank you very much, Admiral Inman. We will have a series of questions.

Let me just ask if Senator Coats has any opening statement that he would like to make at this time, or perhaps he would like to defer until we come back into session?

Senator COATS. I will defer, Mr. Chairman.

Senator BINGAMAN. Fine. On that basis, we will just recess until 10:15 and then begin with Senator Coats' opening statement.

Thank you. [Recess.]

Senator BINGAMAN. The hearing will reconvene.

At this point let me defer to Senator Coats for any opening statement he would like to make, and then we will go into some questions.

Senator COATS. Thank you, Mr. Chairman. I apologize for not being here at the beginning of the hearing to hear these two very distinguished witnesses, and I appreciate very much your presentations and I have your statements, which we will look at very carefully.

I think, given the obvious success of our efforts in the Persian Gulf and the role that technology played, this is a very timely discussion. Testimony before this subcommittee in the past several years has indicated an increasing difficulty involved in separating those technologies critical for national defense from those vital for the competitiveness of U.S. industry in the world marketplace.

It is often the case that commercial sales of goods manufactured in the United States are essential for direct and indirect support of the R&D supporting major defense programs. Studies like the one we have before us this morning that reflect the recognition of this interrelationship can prove very valuable to us as we make decisions on some basic research programs.

The major question for the subcommittee in my opinion is what the next step is. Comparing the list of 22 critical technologies from the Office of Science and Technology Policy with that of the Council on Competitiveness reveals that there is a fairly clear consensus as to what ought to be on that list. What we now have to do is to ensure that those technologies are adequately developed for use in defense programs.

We have control over the funding of individual line items in the budget. Can we influence Department of Defense investment policies in such areas as independent research and development to provide effective incentives for defense contractors to carry out research in these areas as well?

Mr. Chairman, in my view a major item on this subcommittee's agenda for this Congress should be in developing an approach relating our decisions on areas under our control to longer range planning documents, such as the National Critical Technologies Report, and I look forward to working with you and members of this subcommittee on this effort.

Senator BINGAMAN. Thank you very much, Senator Coats. We will insert your prepared statement for the record.

[The prepared statement of Senator Coats follows:]

PREPARED STATEMENT OF SENATOR DAN COATS

Mr. Chairman, I join you in welcoming our witnesses this morning for the presentation of the First National Critical Technologies Report and a discussion of the relationship of the recommendations and analysis in that report with those in the recent Council on Competitiveness Study, *Gainingg New Ground: Technology Priorities for America's Future*. These studies appear on the heels of a large-scale military operation in the Persian Gulf, which demonstrated the importance of advanced technologies for success on the battlefield.

Testimony before this subcommittee over the past several years has indicated the increasing difficulty involved in separating those technologies critical for national defense from those vital for the competitiveness of U.S. industry in the world marketplace. It is often the case that commercial sales of goods manufactured in the United States are essential for direct and indirect support of the R&D supporting major defense programs. Studies, such as those before us this morning, that reflect a recognition of this interrelationship may prove the most valuable to us as we make decisions on funding basic research programs.

The major question for this subcommittee is the next step. Comparing the list of 22 critical technologies in the Office of Science and Technology Policy study with that of the Council on Competitiveness reveals the basis of a fairly clear consensus. What must we now do to ensure that these technologies are adequately developed for use in defense programs? We have control over the funding of individual line items in the budget. Can we influence DOD investment policies in such areas as Independent Research and Development to provide effective incentives for defense contractors to carry out research in these areas as well?

In my view, a major item on the subcommittee's agenda for this Congress should be developing an approach relating our decisions on areas under our control to longer-range planning documents such as the National Critical Technologies Report. I look forward to working with you, Mr. Chairman, to pursue this effort.

Senator BINGAMAN. Dr. Phillips, both you and Admiral Inman might want to comment on this. One of the things we have tried to do in our office is to take the report that you have released today and to take the assessments of where we stand relative to other countries that are contained in the Council on Competitiveness report and try to match those up as best we could to see if we have a consensus. I believe the statements in your National Critical Technologies Panel report are more general.

They are more general and subjective statements than the Council on Competitiveness has tried to come up with. I believe you each have a copy of that chart that we have prepared and they are up on the board here for anybody who can see it.

We have prepared a comparison and tried to take the categories that the Council on Competitiveness used: strong, competitive, weak, losing badly, lost, and match those up with particular technology areas.

Maybe neither of you are prepared to respond here today, but my question is whether you would agree that this is a fairly consensus position as to where we stand.

Admiral Inman, have you had a chance to look at this. Would you be able to respond or would you prefer to do that for the record?

[The information follows:]

National Critical Technologies
U.S. Position
(see endnote for sources)

Materials

Technology	Strong	Competitive	Weak	Losing Badly/ Lost
Materials Synthesis and Processing				
Catalysts		X		
Chemical Synthesis		X		
Membranes			X	
Net Shape Forming		X		
Precision Coating			X	
Process Controls		X		
Electronic and Photonic Materials				
Display Materials				X
Electronic Packaging Materials				X
Gallium Arsenide				X
Magnetic Materials		X		
Optical Materials		X		
Photo resists		X		
Silicon				X
Superconductors		X		
Ceramics				
Structural Ceramics				X
Electronic Ceramics				X
Ceramic Matrix Composites Applied to Aerospace	X			
Composites				
Polymer Matrix Composites				
Aerospace & Military Applications	X			
Commercial Applications			X	
High-Performance Metals and Alloys				
Advanced Metals			X	
Metal Matrix Composites		X		
Aerospace & Military Applications	X			
Commercial Applications			X	

Manufacturing				
Technology	United States Position			
	Strong	Compe-titive	Weak	Losing Badly/ Lost
Flexible Computer Integrated Manufacturing				
Computer Integrated Manfacturing		X		
Flexible Manufacturing			X	
Computer-Aided Engineering	X			
Design for Manufacturing Process			X	
Systems Engineering	X			
Intelligent Processing Equipment				
Robotic and Automated Equipment				X
Precision Machining and Forming			X	
Design of Manufacturing Processes			X	
Advanced Welding		X		
Joining and Fastening Technologies		X		
High-Speed Machining			X	
Micro- and Nano-Fabrication				
Integrated Circuit Fabrication & Test Equipment				X
Thin Films/Surface Treatments			X	
Systems Management Technologies				
Integration of Research, Design, and Manufacturing			X	
Total Quality Management			X	

Information and Communications				
Technology	United States Position			
	Strong	Compe-titive	Weak	Losing Badly/ Lost
Software				
Applications Software	X			
Artificial Intelligence	X			
Expert Systems	X			
High-Level Software Languages	X			
Software Engineering	X			
Microelectronics and Optoelectronics				
Logic Chip	X			
Memory Chips				X
Microprocessing	X			
Submicron Technology		X		
Laser Devices			X	
Photonics			X	
Multichip Packaging Systems				X
Printed Circuit Board Technology				X
High-Performance Computing and Networking				
Hardware Integration		X		
Neural Networks	X			
Broadband Switching		X		
Fiber Optic Systems		X		
Digital Infrastructure		X		
Multiplexing		X		
Aerospace and Military Applications	X			
Commercial Applications			X	
High-Definition Imaging and Displays				
Electroluminescent				X
Liquid Crystal				X
Plasma and Vacuum Fluorescent				X
Sensors and Signal Processing				
Military Aerospace Applications	X			
Commercial Applications			X	

Information and Communications (Continued)				
Data Storage and Peripherals				
Magnetic Information Storage	X			
Optical Information Storage				X
Hardcopy Technology			X	
Computer Simulation and Modeling				
Computer Simulation and Modeling	X			

Biotechnology and Life Sciences				
Technology	Strong	Compe-titive	Weak	Losing Badly/ Lost
Applied Molecular Biology				
Genetic Engineering	X			
Bioprocessing	X			
Drug Discovery Techniques	X			
Bioactive/Biocompatible Materials	X			
Medical Applications	X			
Non-Medical Applications			X	
Medical Technology				
Medical Technology	X			

Energy and Environment				
Technology	United States Position			
	Strong	Compe-titive	Weak	Losing Badly/ Lost
Energy Technologies				
Photovoltaics			X	
Fuel Cell Technology		X		
Pollution Minimization, Remediation, and Waste Management				
Pollution Minimization, Remediation, and Waste Management		X		

Aeronautics and Surface Transportation				
Technology	United States Position			
	Strong	Competitive	Weak	Losing Badly/ Lost
Aeronautics				
Airbreathing propulsion	X			
Rocket Propulsion	X			
Computational Fluid Dynamics	X			
Systems Engineering	X			
Human Factors Enginering	X			
Avionics		X		
Surface Transportation Technologies				
Alternative Fuel Engines		X		
Electric Motors and Drives		X		
Electrical Storage Technologies		X		
High Fuel Economy/Power Density Engines			X	
Low Emission Engines	X			
Intelligent Highway Systems		X		
Maglev technology				X

These comparisons were compiled by the office of Senator Jeff Bingaman using the National Critical Technologies Report, as well as critical technologies reports prepared by the Department of Defense, Department of Commerce, and Council on Competitiveness.

Admiral INMAN. Mr. Chairman, there are a few details that we might change moderately, but in general terms the construction that you have put together is completely consistent with ours. I would underline that the judgments of where we are strong, where we are competitive, where we are weak, where we are losing badly, are largely subjective judgments, but they are made by as competent a group from industry, from each of the sectors, as I believe we are likely to find. And I am therefore prepared to stand with them.

Dr. PHILLIPS. Senator, may I just make one statement on this, and that is, glancing over them, and of course I have seen this Council on Competitiveness report before, I think I would tend to generally agree with the Council on Competitiveness assessments. But I would hasten to add that we nevertheless are not in an irretrievable position anyplace, because of our very strong science base and our strong cadre of scientists and engineers.

We still have an excellent base. We have not utilized our base appropriately in all areas. So that for an instant in time I would tend to agree with these particular assessments, but they can be, given a national will, reversed.

Now, I am not trying to be a Pollyanna on these things. But on the other hand, we are an extremely well-endowed country and, although we have many problems, these things can be addressed where we are weak if we have the will to do so.

Admiral **Inman**. If I may build on that.

Senator **Bingaman**. Yes.

Admiral **Inman**. We were privileged to have Dr. Phillips as an observer and participant through a good deal of our own efforts. There were a few members who believed in the categories that we have listed as losing badly or lost that they were irretrievable. The majority still had the view that even in that category, that we still had the chance, if we were prepared to make the commitment to do it.

As we move to the areas that are listed as weak, there was indeed a consensus that all of those are recoverable if we make enough effort.

Senator **Bingaman**. Let me ask about one of these areas, because I think this gets to the base of what our national policy is. On page 68 of Dr. Phillips' report, you discuss the issue of high definition imaging and displays.

You indicate that we are in great difficulty in that area and state: "U.S. efforts in this area have been extremely limited and capabilities are far behind those of the Japanese and Europeans. Moreover, the prospects for a significant increase in U.S. efforts are poor because"—and you cite two reasons: "Number one, the market prospects are too long-term and high-risk to justify a substantial increase in privately funded R&D; and second, national security requirements alone do not support a major commitment of defense funding."

We seem to be reaching the conclusion here that, even though this is a critical technology and even though we are substantially behind the Japanese and the Europeans by our own admission, we are not likely to do anything about it because it is too high risk for industry to pursue and it is not a sufficient priority of our defense needs to justify an effort there.

Are we saying that U.S. Government policy is that we will permit deficiencies in these critical technologies unless there is a clear, comprehensive need, a requirement in the defense sector? Is that our position?

Dr. **Phillips**. Well, first, Senator, I would respond that the technologies as far as the high-definition displays are concerned are to a very large extent manufacturing technologies. The real problems are in the efficiencies with which one can make these displays.

So as far as basic science and even technologies outside of the manufacturing area are concerned, there are areas where we have proficiencies in, but it is over in the manufacturing side, simply because we have gotten out of the television industry, that we simply do not have an industry that is geared up for working in this area. The Japanese have seven or eight companies that are very heavily involved in the manufacturing of displays. So our deficiency is that we have opted out, for various reasons, to not build television sets, and that is why we are not competitive in this area.

Senator **Bingaman**. Let me just ask one other question. My time is up and I will give additional time to Senator Coats to ask questions. There is a follow-up question here.

In this year's defense budget we put $74.5 million in for work on high-definition displays. In the request to us from the administration sent up earlier this year, the President asked for zero funding in 1992. Is that a reflection of the administration's view that this is an area we are opting out of and essentially plan to have no capability in?

Dr. **Phillips**. I cannot answer that question, Senator.

Senator **Bingaman**. Did you have any response to that?

Admiral **Inman**. If a lawyer were sitting next to me, he would probably advise me not to volunteer on the issue. But since I am without one: My concern as I look ahead to try to draw lessons learned in a different environment, from the Gulf War, and I believe increasingly as you think about the very short time frames to get ready to use technology, the critical roles of command and control, the need to be able to do a federated approach to supporting military operations—we are not going to be able to gather all of the units together—that high definition display of critical information for targeting, for damage assessment, is going to be very high on the list of needs.

I am somewhat more bullish on what I think the long-term national security need is going to be on those devices in my distant view on looking at the issue. There is not an immediate sign of how it is going to pay off, and when you are looking at drawing down the total defense budget by 25 percent over the years there will be a tendency to push out of that budget investment in basic and applied research that is not going to offer a near-term payoff.

But my own view is that the need for the technology in the national security arena is going to be there. Whether we are also going to have the manufacturing base and the willingness to make the kind of investments to look at commercial capitalization of that is a very different issue. There I do not see under current tax policy that we are going to have the incentives to encourage companies to want to get into that business where they do not already have a profitable base.

Senator **Bingaman**. Senator Coats.

Senator **Coats**. Dr. Phillips, on page 11 of your testimony you said: "Where do we go from here? As I have emphasized, our focus should not be on continuing to generate new lists which all say about the same thing, but on doing something to improve the U.S. position."

I think we would all agree on that. I guess my question is, we have a program here which requires a new list to be published every couple of years. Is that spending too much time generating new lists or is it necessary—both of you can answer this, I guess—or is it necessary, given the pace of technological development, that we examine these every 2 years to make sure our list is current?

Dr. **Phillips**. Senator Coats, I think the re-examination every 2 years will be a useful exercise. It will not be nearly so difficult the second time around because one would expect to basically adjust these with respect to slightly varying national needs, slightly varying new technologies coming in from the scientific sector.

So I think it is a useful exercise. But I do not think that things are going to change very much for the future, and I truly believe that it is the implementation process. I do not think it is too much of a burden, though, to continue doing this.

Admiral **Inman**. Senator Coats, my views parallel very closely. We were perhaps a little too flip in our report in saying that it was time to stop making lists and get on with making programs. And that was not to undercut the value of the list that Dr. Phillips has just helped to produce.

I think 2 years is certainly frequent enough. Three might even be all right in the process of updating it. The more critical factor is what is going to be parallel to it, what are going to be the implementing plans and how are those going to be pursued.

And I think unless those are done looking out over about a 5-year base of what you are going to try to do, we simply are not going to be successful. Simply treating it in an annual budget exercise, without something that drives where you are going in the long term, just is going to cause us to miss the mark.

Senator **Coats**. Which we are likely to do, given the nature of the way we make decisions around here.

In that regard, what impact do you think this report will have on budget preparation for agencies as they put together their 1993 budget requests? Is there any indication?

Dr. **Phillips**. Senator, as I briefly discussed in my testimony, the FCCSET, Federal Coordinating Council on Science, Engineering, and Technology, has been one of the major thrusts of OSTP since Allen Bromley assumed office in 1989, simply because it is the only real mechanism that we have at this point for coordinating and rationalizing programs across agencies.

The materials category is a major thrust of the Council on Competitiveness, Critical Technologies, Defense, Commerce Reports, and our own as well. We are undertaking now, after about a year's prior work, a major FCCSET crosscut—it was just authorized on April 15—across all agencies—Defense, NASA, Energy, NSF, Commerce, and so forth—in the materials area to rationalize these programs using this FCCSET mechanism.

Also authorized at the same time was a major FCCSET crosscut, with a different one of the FCCSET committees, in the biotechnology area, which again was one of the major categories that we and others have identified.

So these critical technology studies are being utilized. There are other initiatives of the Federal Government, e.g., the Department of Commerce Advanced Technology Program, in which the results of this National Critical Technologies Study are being used as a guide.

So I think the answer is that it is and will be utilized.

Senator **Coats**. Admiral Inman, in your statement you point out the need for the Government to support pre- competitive research. But the Council on Competitiveness I guess is not entirely clear on just what a conceptual definition of pre-competitive technology is and, more importantly, at what stage it no longer becomes pre-competitive.

Do you have some suggestions as to guidelines we ought to follow so that we do not get into a situation where we are trying to pick winners and losers without letting the marketplace, the competitive marketplace, influence that ultimate selection?

Admiral **Inman**. We elected to go with a definition for generic technology that was used in the policy statement issued by OSTP last fall, which we in fact supported, applauded, as a major step forward. And as we have listed these technologies, we considered that all of them fit in the category at this point of generic technology.

The toughest part of your question is when do you move out of the pre-competitive stage into the competitive stage? My experience at running a joint research venture was that you are less concerned about having moved out of a stage, but rather are you still pushing the frontiers? What I discovered in managing MCC was that we would have research programs running a period of years, but out of the ongoing research activities, if the companies closely tracked it, they found tools that they could use to advance their process, they found elements of the emerging technology that they could either use to improve an existing product or to start on another line.

So our view in the research area of when we were going to be through turned out to be not in congruence with where industry found elements of that emerging technology to use in the marketplace now.

The heart of the problem was the degree to which industry was tracking what was happening in the research and looking to pull out things to use. And we found some companies that were very innovative and others that were still waiting for a box to be delivered with ribbons tied around it saying "This is finished; now how are you going to use it?"

Senator COATS. Do we need substantial tax incentives for them to do that?

Admiral INMAN. I got in trouble with my friends in industry on a suggestion on this over in the House of Representatives a couple of years ago at a luncheon. I think tax incentives really are the key to much of it. Industry probably ought to do it on their own initiative, but they will not.

But there are a whole array of incentives. Investment tax credits work. They can be put on, they can be taken off. On the other hand, you clearly need for an R&D tax credit the certainty that it is going to be there for several years, not just for one year, if it is going to have its effect.

I suggested, just as a wild idea, without having really pursued its impact, that you stage the R&D tax credit, that a certain percentage of it be deductible for having done the research and you get another 5 percent if you turn it into a product within 2 years from the time of your deduction.

What I am looking for are simply incentives to accelerate the time to market, because that is where our foreign competitors are focusing increasingly, and that forces you to deal with the area that Dr. Phillips was talking about earlier, that is the design for manufacture and the whole process, where we really do not do well compared to foreign competitors.

Senator COATS. Dr. Phillips, my time has expired, so I am going to have to ask you to just say yes or no. Do you agree with that? Do you agree with Admiral Inman? Do we need the incentives to make the companies do it?

Dr. PHILLIPS. Absolutely, yes.

Senator COATS. Thank you, Mr. Chairman.

Senator BINGAMAN. Let me just make a point, that what we tried to do in the legislation establishing the panel and asking for the report was to get more than a list. I think everyone is in agreement. And one of the things that we put there was a request that the report contain—and I am quoting now from the statute—"an estimate of the current and anticipated level of research and development effort in the United States, including anticipated milestones for specific accomplishments by the Federal Government, State, private, colleges and universities."

That may not be the best possible wording, but clearly we would like to get beyond the question of listing and talk about what are we actually doing in the way of support in these critical areas.

I notice the report that we have received contains very little of that information. It does have it in the supercomputer area, where we do have a plan of action. As I referred to in my opening statement, it does not have it in a lot of other areas.

Am I fair in assuming that the reason we do not have it is we do not have that information?

Dr. PHILLIPS. That is correct, Senator. And the reason we have it in the computing area is that this FCCSET crosscut had occurred and that information was available to us. But it is very difficult to get this information. Now, we will of course have it in the materials area in the future, as well as the biotechnology area. OMB actually has done a rather crude crosscut in the manufacturing area. So these informations will be available in subsequent studies.

We had thought that we would put out an interim report in the next year and provide those additional data. We also expect the Critical Technologies Institute to be a big help in this.

We apologize for this. We simply were unable to get the information together.

Senator BINGAMAN. I do think that one of the major benefits of the biannual reports is that it will give us that information and allow us to judge it. One of the concerns that I have had and I have repeated to probably each of the witnesses before, is that we have items on our critical technologies list that get essentially no funding requests from the administration.

That is a kind of an inconsistency that I think is hard for us to understand.

Let me ask on a little more general level. As you read through the report, it strikes me at least that when you get outside those sectors that are heavily influenced by a government mission, we do very poorly relative to other countries. Now, maybe that is too harsh a statement, but I would like your reaction.

What I am talking about is we are good in aerospace applications. I mean, we do very poorly in applications. We are good in aerospace applications because of the Department of Defense and NASA. At least they are a significant factor, I think.

In advanced materials and supercomputing, we have great capability in aerospace and the application of supercomputing there. We do well in medical applications of biotechnology because of Health and Human Services support. We do okay in agriculture because of the U.S. Department of Agriculture's support.

But when you look at other areas of application, we seem to lag. My question is does this tell us that we have got to do something different in the structure of our Government, or does this tell us that there is something inherently uncompetitive about our industry?

I know this is something that, Admiral Inman, was referring to just a minute ago, about how we need more tax incentives to get industry to actually take technology and apply it to produce a product. Is there something that needs to be done on the restructuring of Government to fill in these needs, or can we do it all by adding some additional incentives for industry?

Admiral INMAN. Senator, we found in our effort that there are some industries that do very well that have not had strong Government support: the chemical industry, which is in fact very viable and very competitive. Pharmaceuticals has some Federal research base to draw on. And we spent some time trying to understand all that.

There are major issues here of the availability of capital, the cost of capital, and the need for it; how capital intensive is the technology area that you want to pursue? And that cut across and had some significant impact.

It was very clear, as I indicated in my earlier remarks, that where there was strong Government support we did well. There were a few areas without that Government support we did well, but too many where we did not. So it is a mix for me of in some cases direct Government investment, in others intelligent procurement policy that ends up facilitating the process, in others tax policy.

Most of all, ultimately it is the environment that Government helps to create that encourages industry to in fact compete.

Senator BINGAMAN. Dr. Phillips, did you have some comments?

Dr. PHILLIPS. Yes, I do. I agree completely with what Admiral Inman has to say. I spent 30 years in the chemical industry myself, so I very much appreciate those comments. But there are some differences that are worth looking into with respect to, say, the chemical industry, which has been one that has been independent Government support in any way, except for the support of basic research in chemistry and physics and other disciplines that it utilizes.

The important thing, I think, to understand about the U.S. chemical industry is it is a fairly old industry, and that it only began becoming prominent after or during World War I. Prior to that the German chemical industry basically dominated the world and the U.S. chemical industry was a relatively modest operation.

But the American chemical industry really came into its own following World War I. It has been used to competing for a rather long time. It did not start off as number one. It started off as number two or number three, and it has wrested its leadership in global competition.

The other thing I think—and I am only using this as an example of what may be different, but by the very nature of the chemical industry, dealing with fairly hazardous and toxic materials, the manufacturing processes have been built into the discovery process. So there has been a smooth transition of product from innovation through process work to manufacture.

Senator BINGAMAN. Is not the point that you made before, Admiral Inman, also valid, though, which is that the products that the chemical industry sell are closer to basic research and, therefore, we are able to be competitive in chemicals as well as in pharmaceuticals more easily than we can do that without a significant effort at manufacturing?

Admiral **Inman**. Let me venture a little deeper into the water, that it is not a question of picking winners and losers of companies. I spent 30 years in Government service. I have wonderful memories from it. But quite candidly, in looking at the talent we attracted, including Inman, I would not want to put in the hands of Government employees the decision on which companies would be supported and which would not.

But I think as you stand back and look at the issues of how much research has to go into a field in order to have technology exploitable, that we can make choices sensibly as a country in that process; and that as you look at where is there going to be a long period of investment necessary before there are likely to be outputs, those are clearly areas where we can understand the need for either different tax treatment or for additional support, not as playing favorites for an industry, but just recognizing the reality that there is a lot longer string there to get to the product and that you need to create an environment that will ensure you get all the way down to success.

Senator **Bingaman**. And you are talking about industries like information, communications, things that relate to those general areas of activity.

Admiral **Inman**. Clearly, where there is a short cycle from basic research to product, we want to sustain a vibrant level of investment in that basic research. But there we want to look largely, looking at the Government role, what you do with the regulatory process to facilitate the speed with which the products can be on the marketplace, and so on.

You have got a very different approach when you are looking at the process technologies: How do you in fact facilitate broadly across a variety of industries the ability to shorten that time to market cycle?

Senator **Bingaman**. Let me ask a few questions on another couple of specifics. Advanced lithography, X-ray lithography, that is an issue that I hear about every year, and we always have a little debate on it here in the Congress as to what we should to do in the area of funding for research in that area.

This year we are putting $60 million into that through the defense budget, as I am informed. Again, the administration has asked for no funding next year. That is consistent. We seem to have that little dance every year. They ask for no funding, we put in money.

Is this something we need to continue to support or should we drop it out and opt out of X-ray lithography? Do you have views on that, Dr. Phillips or Admiral Inman, either one?

Dr. **Phillips**. My view is that we cannot opt out of areas like X-ray lithography and E-beams, that is, areas of fabrication and design of semiconductor circuits. This is the very heart to modern industry and there is absolutely no question it is going to continue this way, and we cannot let these things lag.

Now, the question is how do we get these things back on track? Certainly Government funding is one route, but we have got to have commitment on the part of the private sector or these things simply will not happen.

Again, I believe that the Government has major responsibilities in these pre-competitive areas because I think these are general capabilities that we must possess. But we have got to find mechanisms in which we have the appropriate industry commitment, and these may include Government regulations that need to be changed, tax incentives, etc.

But we must have the full involvement of our private sector, their best people, with them buying into the process. They are not going to do it if funds are just given to them. Industry has got to buy in with their own resources of both people and money.

These are the kinds of problems that we must learn to solve better than we have.

Senator **Bingaman**. You have referred to manufacturing as an area where OMB has done a rough estimate of where we are. My rough crosscut, totally uninformed as far as any expert analysis goes, is that by far the largest Federal amount of resources going in to upgrade manufacturing is through the defense budget. I think this year we have something like over $300 million going into manufacturing, most of it through the MANTECH program.

There are arguments as to how well all of that is being spent, but at least we have that dollar figure in there. Again, we have an administration request to go from $305 million down to $97 million in funding for that area.

If in fact manufacturing is one of our areas that is essential and critical to the country and where we are consistently falling behind, what do we need to do to energize the administration to give attention and resources to this. What is the role for the Federal Government?

I understand that the Federal Government cannot fix the problem of manufacturing, but surely there are things that other governments are doing that we could assist in, that would be at least pointing in the right direction?

Dr. Inman, maybe this is a better question to ask you. Dr. Phillips, I am glad to hear your views, too.

Admiral **Inman**. Senator Bingaman, I have tracked the MANTECH program for a number of years, never had a role in administering it. I believe it has been a forward-looking program that merited support, and should continue to be supported.

The problem is in linking the actual product results with weapons systems procurements and getting some linkage where there is clearly a priority for the companies and for the program managers, that the most modern techniques are being committed at the outset and being employed throughout. When you have got a fundamental approach that says the only factor that matters in deciding which bidder you are going to go with is cost, then there will be little focus on what is being done in the use of modern technology, in the process that says the next time around, not only will this be a better product or a better quality, but the next one will also be less expensive.

The tendency, if your only measure is competitiveness, is simply use the existing approach, the existing facilities, less risk because you are not introducing the uncertainty of change, and go with that in your bid.

So I go back to some degree to approaches that I found in the study out of CSIS that I think begin to tackle the problem. If you will permit me to go on just a little longer on this topic, having watched both Democratic and Republican administrations—I have been around long enough to have done that—and to watch their interaction with Congress, the problem is the single year budget.

It did not matter who was in power in the executive branch. There was always a reluctance to share information about plans beyond the year in which the budget discussion was going to occur, and there was a reluctance to accept additions from the Congress specifying specific areas for investment or programs.

I ultimately became persuaded that the best way out of that was to try to go to multi-year authorization, multi-year appropriations, where the primary debate between the Congress and the executive branch was over priorities and not over single line items. And I think there has to be some pretty strong guidelines of expectation that you reach: What is the level of investment in basic research and applied research that ought to occur in the defense budget?

I believe over the last decade it has been skewed much too much in the 6.3.B, 6.4, 6.5, 6.6, and not enough in the 6.1, 6.2., 6.3.A. What I have searched for are mechanisms that would produce a debate that would look at areas where there is a broad agreement on the need to invest, and then look at these needs that are 5 to 10 years out: What are the investments over the next 3 years that are planned?

I think as long as we are still in an environment where there are single year budgets that the debate is again going to be one more of ownership and turf, about who gets to decide what the line items will be for that year, and that we really do not get into the argument of priorities.

Senator BINGAMAN. We get approached by the administration fairly frequently to approve multi-year procurements of weapons systems. What would be wrong with us having multi-year authorizations in each of these critical technology areas?

Admiral INMAN. I happen to think it would be a superb approach.

Senator BINGAMAN. You agree with that, Dr. Phillips?

Dr. PHILLIPS. I think program continuity, or lack thereof, is one of the big problems that we have. Industry cannot plan. No one can plan when regulations are subject to marked change on a short-term basis.

An example is the R&D tax credit. A lot of companies have not really attempted to utilize it because they could not count on it being there the next year.

Senator BINGAMAN. You are basically in agreement that what we have done in supercomputing, which is to lay out a 5-year plan and specify what level of support and effort we are going to have in each of the Federal agencies concerned with that, that that same process should occur in each of the other areas that are of concern to us, so that people can look ahead 5 years and say, we are going to have a significant national commitment to this and therefore it is worth our while to concentrate on it?

Dr. **Phillips**. Yes, sir.

Admiral **Inman**. Senator Bingaman, as you know I would love to do this across the whole budget process. I recognize that is too large a goal to try to get. But it seems to me since we do have a consensus pretty broadly on what the critical technologies are, at least for those areas doing a multi-year approach is a good place to start tackling the problem.

Senator **Bingaman**. In manufacturing, at least by the accounts, we are in difficulty in competition with other countries. What does that tell us about the policy we should pursue to cooperate with other countries?

Particularly, here I am eliciting any ideas or opinions that either of you would like to express on the IMS proposal. I will tell you my own perception going into it. The Intelligent Manufacturing Systems Proposal that the Japanese made to both the United States and Europe a year or so ago, based on what I have seen, could if properly defined hold some real promise for us to begin to upgrade our own manufacturing in areas such as systematizing and documenting manufacturing techniques that are in place elsewhere and hopefully implementing some of those here.

I have become frustrated watching the slowness with which we have reacted to that. It seems that our position now is, through the Department of Commerce, that we are proposing back to the Japanese that we would like to study this for 18 months to see whether or not it is something we ought to do, whereas we have already been going back and forth for about a year on it.

I think the underlying assumption our Government seems to be operating on is that we are scared that they may learn something from us that would be to their advantage, when in fact we have no restrictions on foreign researchers in our universities, we have no restrictions on their ability to access virtually any information we are developing in these areas. But we seem reluctant to sign onto any kind of cooperative effort with foreign governments.

Dr. Phillips, if you have a view I would be anxious to hear it.

Dr. **Phillips**. Yes, I very much do have a view on the intelligent manufacturing systems initiative of the Japanese. We have been reasonably close to it in OSTP.

First off, I think Commerce has done a good job in a very difficult situation. The Japanese—and I can do nothing but applaud them—spent a couple of years in background work before they surfaced the initiative.

But we and the Europeans had to do our home work in the face of the Japanese initiative. Commerce did in my view, a very good job on a difficult situation. What was required was input from the private sector on how best to respond in ways that we could be fairly sure that U.S. interests would be protected.

Advantages could be seen. A number of U.S. companies were quite willing to join the initiative on their own. A number of U.S. universities were anxious to join the prospect of funding.

Commerce spent a lot of time with the private sector, eliciting their input on IMS. It was generally agreed that a year's trial period would be in order.

There have been some difficult problems in interfacing with our private sector in this matter. However, I think the process is working. No matter how this initiative comes out, there have been some real plusses in getting elements of our private sector talking among themselves and also talking with people in the Federal Government.

But this was a long-winded response to your question. I think this has been a useful process and probably a positive one up to this point.

Senator BINGAMAN. Do you think it is something that we should put some dollars into? As I understand it MITI has committed $400 million and we have committed zero at this point. To indicate our willingness to proceed in good faith, should the Federal Government indicate this is something that they are willing to at least put some seed money into?

Dr. PHILLIPS. I think ultimately the Federal Government should be putting some money into this program, if it progresses as expected. But I do not see anything particularly wrong with the process that is being developed in which companies that want to participate will buy into the initiative at certain levels, depending upon their size, and so will universities, to form initial pools of funds.

I am a firm believer in commitments by beneficiaries. Ultimately some Federal funding possibly should be channeled into the IMS initiative, but I do not have any problem with asking for commitments of our companies and our universities that want to participate.

Senator BINGAMAN. Admiral Inman.

Admiral INMAN. Senator, this is an area where I have little knowledge. I have not studied the proposal. Just a reaction from listening to the conversation is that I would not feel badly at all if the Japanese did the bulk of the funding for the effort, because they draw on so much of our technology base at essentially no cost. They certainly profit greatly from the major investment we make in our university research along the way.

I think the underlying problem here is changing culture in U.S. industry with regard to time horizons. The Council on Competitiveness has a major effort under way trying to understand why are U.S. firms in many instances so much slower to use the technology than their foreign counterparts. And that effort is a few months away. I hope maybe it will give us some additional ideas on things we need to do in the policy arena.

Senator BINGAMAN. There are a lot of other questions I could go into here, but I think you have all been patient and generous with your time, and I will stop with that and again compliment you, Dr. Phillips, on the report. I think it is a significant thing for our country that we have a National Critical Technologies Panel issuing a report and trying to for the first time identify priorities for the country as a whole. I hope very much that the report is given the attention it deserves and I hope that the Council on Competitiveness report, which is a very good complement to it and provides additional detail and insight about the very same issues is given the attention it deserves as well. I think that the two of them together advance the debate very substantially, and I hope very much we can continue to work with both of you in trying to ensure that Congress does its part to move us down the road.

Thank you very much for being here, and we will continue to pursue these issues.

Admiral **Inman**. Thank you, Senator.

Senator **Bingaman**. We will conclude the hearing.

[Whereupon, at 11:08 a.m., the subcommittee was adjourned.]

DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993

TUESDAY, MAY 7, 1991

U.S. SENATE,
SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

DEFENSE CRITICAL TECHNOLOGIES PLAN

The subcommittee met, pursuant to notice, at 9:31 a.m., in room SR-222, Russell Senate Office Building, Senator Jeff Bingaman (chairman of the subcommittee) presiding.

Committee members present: Senators Bingaman and Smith.

Committee staff members present: Madelyn R. Creedon, counsel.

Professional staff members present: William H. Smith.

Minority staff members present: Jonathan L. Etherton and Mark B. Robinson, professional staff members.

Staff assistants present: Elizabeth Ann Harlow and Camden Jones.

Committee members' assistants present: John P. Gerhart, assistant to Senator Bingaman; Anthony H. Cordesman, assistant to Senator McCain; Eric H. Thoemmes, assistant to Senator Coats; and Thomas L. Lankford, assistant to Senator Smith.

OPENING STATEMENT OF SENATOR JEFF BINGAMAN, CHAIRMAN

Senator BINGAMAN. The subcommittee will come to order.

Today we will receive testimony on the third annual Defense Critical Technologies Plan. The plan which we originally prepared in the 1989 Defense Authorization Act, is meant to serve as an important management tool for both the executive branch and the Congress. It occurred to us in 1988 that critical long-term technologies were not getting the attention they deserved in the DOD budget and planning processes. This subcommittee lacked confidence that we were properly allocating the resources to the truly priority areas in a reasonably coordinated fashion—"coordinated" not only among DOD's various components, but also with the private sector and with other Federal agencies, particularly the Department of Energy with its large defense-oriented defense technology base in the weapons area.

I have only had a short period to look over this latest plan, but it seems to me that it is a substantial improvement over last year. However, we are still struggling to turn this into a document that can actually make a significant difference in the way we do business. We certainly have an improvement this year in the quality of the budget information provided for the various DOD components, although not for the Department of Energy. I do get worried, however, when I see over 50 percent of the non-SDI Science and Technology program is now defined as critical. My concern is that the categories are being defined too broadly. The question more specifically is whether 90 percent of DARPA's budget should be defined as critical.

I am also concerned that last year's attempt to set priorities among the 21 technologies identified, at least in three broad tiers, has not been repeated. When over half of the DOD science and technology budget is "critical," it becomes all the more important to differentiate among the technologies.

Another improvement this year is the attempt to provide not only static comparisons with other nations' efforts in developing these technologies, but trend comparisons as well. It appears that the assessments done this year are among the most optimistic trend comparisons that I have seen. They are certainly more optimistic than those that the Department of Commerce had in its Emerging Technologies Report and more optimistic than those that the Council on Competitiveness had in its report, "Gaining New Ground," that was issued fairly recently.

The explanation may be that the Department of Defense is focusing only on military applications of these technologies, but given the strong trend toward integration of commercial and military technologies, I frankly doubt our ability to remain preeminent in military applications, which often constitute a small and diminishing fraction of the market, when the trends in commercial applications are so adverse to this country. The plan itself states that the commercial military technology convergence "is likely to become more pronounced as advanced weapons systems become increasingly dependent upon information technologies".

While there have been improvements in many details of this third plan, I am still concerned that it has yet to become a real management tool. We still do not have a good sense of how the available resources, not only in the Department of Defense and the Department of Energy, but in other Federal agencies in the private sector, will be applied to reach the identified milestones and objectives for the 21 identified technologies. We still do not know who is responsible for the overall effort in each technology.

My sense is that the first two defense critical technologies plans have been relatively ineffective in changing the way the DOD manages its technologies and its science and technology program more broadly or in how the Department of Energy manages its defense program technology base. I have yet to see any significant effect on DOD's international cooperative research and development activities, especially with Japan, which the latest plan continues to identify as a capable major contributor in 5 of the 21 technologies: semiconductors, photonics, machine intelligence, robotics, superconductivity, and biotechnology. It is identified also as making an important contribution in 6 of the remaining 16.

At this morning's hearing, we will discuss how the two departments, the Department of Defense and the Department of Energy, intend to use the plan, how we can together turn it and the process used to prepare and implement it into a core activity of the research arms of the Department of Defense and the Department of Energy Defense Programs Office.

We will hear from three witnesses: Dr. Charles Herzfeld, who is the Director of Defense Research and Engineering at the Department of Defense; Admiral Michael Barr, who is the Deputy Assistant Secretary for Military Application in the Department of Energy's Defense Programs Office; and Mr. John Swihart, who will be speaking in his capacity as President of the National Center for Advanced Technologies and Vice Chairman of the Aerospace Industry Association (AIA) Technology Policy Forum.

Dr. Herzfeld has had a long distinguished career in government and industry managing large research programs. Admiral Barr has throughout his Navy career had broad exposure to the management and application of technology to meet military needs. Mr. Swihart has been at the heart of the aerospace industry's efforts to develop a coherent technology strategy and detailed road maps for the technologies that that industry has identified.

I should note that AIA's efforts predate those of the Department of Defense. My conversations in 1988 with people like Tom Murrin, who was then at Westinghouse, strongly influenced my original ideas as to how to proceed to rationalize our long-term defense technology efforts.

We look forward to the testimony this morning. After the three statements from the witnesses, I will have some questions.

Before we proceed, I will enter into the record the prepared statement of Senator Coats.

[The prepared statement of Senator Coats follows:]

PREPARED STATEMENT BY SENATOR DAN COATS

Mr. Chairman at the hearing this subcommittee held on April 25, the witnesses presented us two similar lists of critical technologies along with some general policy recommendations. The recurring question was: Where do we go from here? How do we get beyond drawing up a series of similar lists to a longer-term strategy to ensure the development of the critical technologies.

Mr. Chairman, I commend you for your leadership in directing the Department of Defense to establish a process for connecting long-term strategic planning for technology development with the shorter-term planning, programming and budgeting process in the Department of Defense. The DOD Critical Technologies Plan has been the mechanism to force this process. Over the last 2 years the annual DOD plan has evolved to serve more effectively as a planning tool. We must ensure that the plan is a central factor in the resource allocation process.

If we are to continue to develop the technologies in the Critical Technologies Plan, the private sector must play a pivotal role. The Aerospace Industries Association and the National Center for Advanced Technologies are spearheading an important effort to direct and stimulate cooperative investment in the research and development in the private sector. Their program focuses heavily on action and is a model for other industry sectors to follow to meet the challenges of the next 10 to 15 years.

As we discussed on April 25, making long-term planning a reality in the technology area in the Department of Defense will take many years of sustained oversight by this subcommittee as well as others in Congress. Mr. Chairman, I look forward to working with you to continue the work you have pioneered on this issue.

Why don't we start with Dr. Herzfeld and have you proceed with whatever presentation you would like with regard to the plan.

STATEMENT OF DR. CHARLES M. HERZFELD, DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING, U.S. DEPARTMENT OF DEFENSE

Dr. **Herzfeld**. Mr. Chairman, ladies and gentlemen, I am honored to be before you again today to present this year's Defense Critical Technologies Plan and to give you an overview of the Department of Defense's Science and Technology program.

What I would like to do, with your permission, is to present some excerpts of the prepared statement and have the prepared statement included in the record.

Senator **Bingaman**. We will include all of the statements in the record in full, and if you could summarize it, that would be great.

Dr. **Herzfeld**. Thank you very much.

We have come a long way, as you pointed out. I think we are in much better shape in terms of this being a real plan, but I agree with you. We are not there yet. While I am somewhat pleased, I am not satisfied at all. More needs to be done. We acknowledge that quite freely, and we look forward to more progress in future versions.

Very briefly, it is important to recall that the recent conflict in the Middle East showed that the fundamental investments that have been made in the past were at least approximately right. We wound up with a rather impressive military capability on the basis of these investments. That makes it all the more important to have the right investment strategy now and for the future so that if such contingencies should occur, say, 10 years from now, we will be similarly well prepared then and similarly able to carry out the missions that we are asked to carry out.

The Department of Defense is making a careful analysis of how our military systems performed, and these lessons learned will be made public when the studies are completed, to the degree that that is appropriate.

We do remain committed and totally convinced that the technological base is essential to have the technological superiority that we had and that we need to continue. President Bush pointed this out last August at the Aspen Institute in his speech that—and I am paraphrasing—that an active and inventive R&D program is essential for our national security. The Secretary of Defense, the Deputy Secretary, the Chairman of the JCS, and many others have elaborated on this. I do not need to go into detail on this with this audience, which understands this perfectly well.

The changes in the world over the last several years have made our job in some ways easier and in some ways more difficult. The threat of a no-warning attack in central Europe seems to be gone, at least for a while, perhaps for a very long time. On the other hand, we know that advanced technology is flowing into hands of those who do not have our national interests at heart and that ballistic missiles of various ranges and warheads of mass destruction are becoming available to more and more countries. This presents a new national security problem. In addition, conventional warfare technology is becoming extremely effective and is also being distributed more and more widely. This makes our job in the future more complicated. One of the many things that we need to do is to continue the leading edge of the defense technology to make sure that our weapon systems are the best that we can have.

With this background in mind, the questions for today are really simple. Do we know where we want to go with defense technology? I think the answer is yes. I think the critical technologies plan shows more detail than ever before in the history of the Department, the technical objectives that we have picked as being critical for the development of the future weapon systems. For each of the 21 technologies we have identified anywhere from 3 to 10 subtechnologies; and for each of these, we have technical milestones, technical objectives for the next 20 years. They are not all equally completely described, partly because of inhibitions of ignorance, and partly because we simply do not yet know enough to set clear objectives. There are also concerns about security so that one really cannot tell absolutely everything one plans to do in complete detail in a public medium, but I think we do know where we need to go.

Do we know how to get there? Yes, I think so. The technical objectives set the goals, and the management system which we are constructing now will get us there in a highly integrated manner.

Last, but not least do we have the resources to get there? I think the answer is yes, as far as we can see today. And, of course, we are committed to coming in with proposals for changes in the resource requirements when those changes become clearly necessary. This will happen in the context of the Department of Defense's budget planning process, and I will comment on that further.

I will further address your very important comment that only about 50 percent of the science and technology funding is, in fact, devoted to critical technologies. It is a very important point. There is a reason for it which I think is important to explain.

Senator BINGAMAN. Let me just clarify. The point I was trying to make was that it seemed to me we were defining them so broadly in order to demonstrate a commitment. Yes, I didn't want you to think I was suggesting too little.

Dr. HERZFELD. To address your point, which is a very important one, I think the way we characterize the funding, and particularly by identifying it by program element, which you asked for and which we have done, we have made more precise the use of the terms. Using the subtechnologies in each of the critical technologies has made it easier to come to grips with the issue: is or is not the particular piece of work part of the critical technologies? On the other hand, the valid question arises, is 50 percent the right answer? I think it is close to the right answer. I will discuss that in a bit more detail later. These are delicate issues because you can overdo it or underdo it; and we do not want either of those, but I think we are getting close to having it right.

It is very important to me that I offer a major apology. The plan is terribly late. It should have been in your hands by March 15, and the final version arrived this morning. I am chagrined and ashamed of that; but the plain fact of the matter is it turned out to be very much more difficult to do a good job than we had expected. When we saw where we were headed at the end of last fall and early winter, it was clear that that was not going to be responsive to you or to our needs; and so we basically started over. Some of the ground work was done, and that was useful; but we had to recast the whole scope of the work. That was done and we got a lot more people involved. I can discuss that if you like later. But the upshot of all this was that we simply could not do it any faster.

I would like to give my personal heartfelt thanks to everyone who helped. Many people spent almost all weekends and many evenings and some nights on this, and I think it shows, but we were late still.

Senator BINGAMAN. It is obvious that there is a lot more thought in the report this year than in previous years.

Dr. HERZFELD. I appreciate that very much, Mr. Chairman.

Also, parenthetically, I got a lesson in how many people in the system think they can help by suggesting changes, but I will not dwell on that.

I think we are largely responsive to the legislation. We are not totally responsive; and you described one issue, namely the prioritization, and another one that we have not yet identified, lead institutions for the key technologies. I will address both points later. This was done deliberately, and I will explain why.

I think I can go over rather quickly some of the things in the prepared statement, but I do want to mention briefly a concept that we have developed over the year that is helpful in understanding who is doing what and why.

We see development for defense R&D broadly speaking, come in three different streams of effort that are really quite distinct.

One is the mainstream of evolutionary improvement of weapon systems where one improves what one has, or the new weapon systems are somewhat improved over older ones. Most of this effort is carried out by the services quite competently and quite adequately.

The second stream consists of highly leveraged breakthrough technology. One can make an order of magnitude difference by better sensors, by better engines, or by better armor. This kind of work is focused primarily in DARPA.

The last stream, which is kind of a target of opportunity matter that I think is quite essential, is to look for technology trump cards which arise every now and then. They are matters of opportunity. It is important to give examples. The most recent one was stealth aircraft, which, when it was first thought of, was an idea that many people did not believe was feasible or important; but as soon as a model was built that was a flying model—and incidentally, that was done by DARPA, and the classified program was just unclassified a few weeks ago—it became clear that this was a technology trump card in the sense it has changed the way we think about warfare and the way we do it. Never again will a military aircraft be designed or built without a lot of considerations about how stealthy should it be, how stealthy must it be. Can we afford to make it as stealthy as we would like? That is a pretty powerful change. A much older change that we all are aware of is the atomic bomb, which changed forever the way we think about warfare.

Now, my view is that this country needs to have a succession of these trump cards available to be used when needed at a rate of perhaps every 5 or 10 years in order to continue our dominance of military technology, which I personally believe is essential for our national security.

I have in the prepared statement a discussion of some of the aspects of our technology strategy. I will just mention them briefly.

We must ensure modular design in our new platforms so we can easily upgrade them, and we must have a vigorous and energetic program to upgrade the subsystems of the platforms we have and of the platforms we build by putting in new subsystems, new avionics, new weapons, new engines, new radars, whatever.

Incidentally, we are developing a computerized management system that allows us to predict with some confidence when these needs will arise, for what systems they will arise, and what kind of performance levels will be required in order to make significant improvements. This is something which is still in the works. It is at the moment an internal demonstration model, but when it is finished, it will not be hard to use. Many of the contents of this are classified because it is that detailed, but it will be an important management tool when we get it on line.

We need to focus as part of the strategy very, very heavily on science and technology 6.1, 6.2, and 6.3a. We heard your message of several years ago. It was a message that I personally agreed with then and have agreed with ever since. And I must say the consensus on this point is truly remarkable, both inside the Department, within the military departments, in the Congress, and between the Congress and the Department. I think we are really on the same wave length fundamentally, and what disagreements that may appear in hearings or in legislation really have to do more with implementing this objective and different views about how to proceed. I think in an enterprise as complicated as this, that is something you have to expect. I think we have to face the fact that we are all colleagues in doing this together; and that when we disagree about how to do a piece of it, that is also part of being in a large, complex professional enterprise where everyone has slightly different roles to play and where differences of opinion and of judgments really should be treated as normal and resolved as best one can.

The plan which is before you will be the tool that we will use to implement the program. If I may show the first viewgraph, this is a list of the critical technologies. There are now 21, as you observed. We added flexible manufacturing, and the way we define it is a rather broad subject. But we felt it could not be left out and have the kind of impact that needs to be made. I think we are fully responsive to the thinking of the committee and others in the Congress.

Defense Critical Technologies

1	Semiconductor Materials & Microelectronic Circuits	The production and development of ultra-small integrated electronic devices for high-speed computers, sensitive receivers, automatic control, etc.
2	Software Engineering	The generation, maintenance, and enhancement of affordable and reliable software in a timely fashion.
3	High Performance Computing	High performance computing systems having 10^3 fold improvements in computation capability and 10^2 fold improvements in communication capability by 1996.
4	Machine Intelligence & Robotics	Incorporation of aspects of human "intelligence" into computational devices which enable intelligent function of mechanical devices.
5	Simulation & Modeling	Visualization of complex processes and the testing of concepts and designs without building physical replicas.
6	Photonics	Includes ultra-low-loss fibers and optical components such as switches, couplers, and multiplexers for communications, navigation, etc.
7	Sensitive Radar	Radar sensors capable of detecting low-observable targets, or capable of non-cooperative target classification, recognition, and/or identification.
8	Passive Sensors	Sensors not needing to emit signals to detect targets, monitor the environment, or determine the status or condition of equipment.
9	Signal & Image Processing	Combination of computer architecture, algorithms, and microelectronic signal processing devices for near real-time automation of detection, classification, and tracking of targets.
10	Signature Control	The ability to control the target signature (radar, acoustic, optical, or other) and thereby enhance the survivability of vehicles and weapon systems.
11	Weapon System Environment	A detailed understanding of the natural environment (both data and models) and its influence on weapons system design and performance.
12	Data Fusion	The machine integration and/or interpretation of data and its presentation in convenient form to the human operator.
13	Computational Fluid Dynamics	The modeling of complex fluid flow to make dependable predictions by computing, thus saving time and money previously required for expensive facilities and experiments.
14	Air Breathing Propulsion	Light-weight, fuel efficient engines using atmospheric oxygen to support combustion.
15	Pulsed Power	The generation of repetitive, short-duration, high-peak power pulses with relatively light-weight, low-volume devices for weapons and sensors.
16	Hypervelocity Projectiles & Propulsion	The ability to propel projectiles to greater-than conventional velocities (over 2.0 km/sec), as well as understanding the behavior of projectiles and targets at such velocities.
17	High Energy Density Mater	Compositions of high-energy ingredients used as explosives, propellants, or pyrotechnics.
18	Composite Materials	Two or more constituent materials that are combined together in such a manner to produce a substance possessing selected properties superior to those of its individual components.
19	Superconductivity	Makes use of the zero resistance property and other unique and remarkable properties of superconductors for creation of high-performance sensors, electronic devices and subsystems, and supermagnet based systems.
20	Biotechnology	The systematic application of biology for an end use in military, engineering or medicine.
21	Flexible Manufacturing	The integration of production process elements aimed at efficient, low cost operation for small, as well as high, volume part number variations, with rapidly changing requirements for end product attributes.

We have changed some of the definitions slightly, as you will see in the report. What is even more important, we have introduced the subtechnologies which make more precise what it is we mean by, say, semiconductor materials and such. They mean some quite specific things.

By the way, this addresses one of your general observations. It is indeed true that our approach to the critical technologies is primarily driven by the military needs. Now, we are all pleased if there is a dual use opportunity because we are quite clear that dual-use is important. But the Department has a very strong view that it is not our primary purpose to fund things whose primary utility is in the civilian sector. So, this is a delicate balance we have to walk. And I suspect we will have disagreements in points of views about that as time goes on, but I think we will manage to work through those disagreements.

Now, the program stands behind all of this, and this is embodied in the large, elaborate plan, which will be the principal vehicle for managing the program. The plan was drawn up by a good many people in the Defense Department. We had help from industrial associations, including Mr. Swihart's and others. We had help from the DOE. We had help from other parts of the government. We asked some of the best laboratories in the country to help us pinpoint some of the details so we have had a lot of help which we again gratefully acknowledge.

I was very impressed by the recent report by the Council on Competitiveness and the critical technologies that it identifies. Exactly as you suggest, we focused on the part of their story that has mostly to do with defense, but from an overall national point of view, it is clear that their list is a very thoughtful one. I think, in fact, many of the things that they recommend be worked are impacted positively by our program.

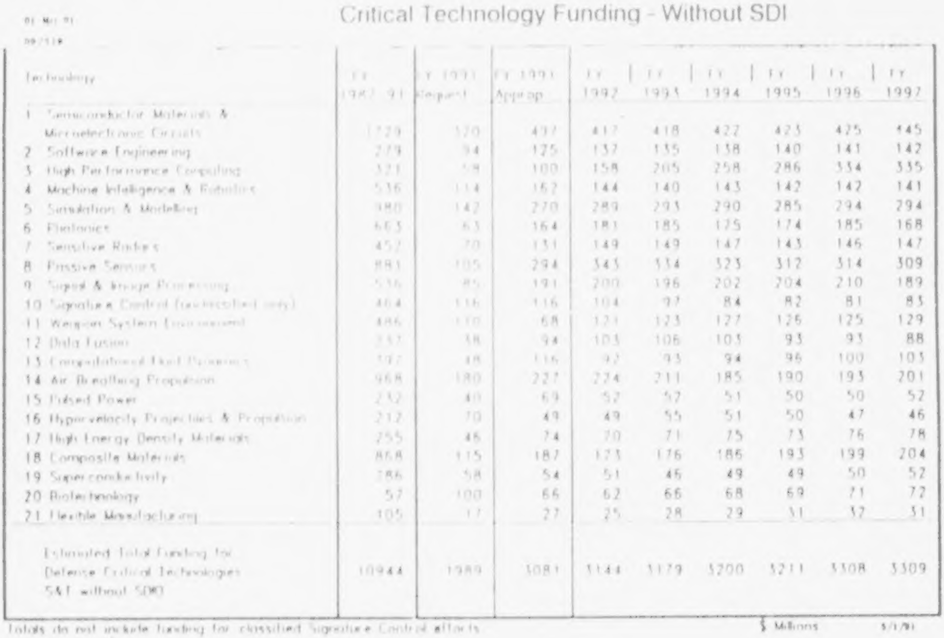
We started our planning work from last year's plan but went through the whole drill from top to bottom all over. We went through each of the program elements. Each program element in the Department, as you know, has a number of tasks or programs in it. We analyzed each of those; identified those that did support the critical technologies as we had defined them; and then compiled the resources that were identified in this way in Annex A of the plan, which gives, as you required, program-by-program element, which critical technology is supported and by how much. This is a new item. It is very important for our management and embodies the commitments which were made at the end of the planning cycle by the military departments and the defense agencies about the program they are going to carry out. So, this is a plan that is accepted by and will be executed by the departments.

The plan for this calendar year now is to go back, review the programs of fiscal year 1991, see how they are doing, look at new needs that we have identified, including lessons learned, for example, from the Gulf, and then propose internally within the Department, within the PPBS process, modifications to the current program which will show up as reprogramming requests for fiscal year 1993 and in the fiscal year 1994 Presidential budget. So, that is the route that we are going to take with this plan. It will be the jumping off place for our preparation of input to the 1994 budget and the 1993 apportionment.

I think in that sense this should give you a sense of comfort that this is not just a piece of paper. This is our instrument for managing the program and for planning the next program, which will be an evolution from this program. We plan to continue in this mode until a better method comes along, which no doubt will happen with your help and many others'.

I think it is important to be clear about that. Last year's document was kind of a static one, as you explained; and we see this as a dynamic one, again a snapshot to be sure, but of a dynamic process which we have instituted during calendar years 1990 and 1991.

One very important consequence of this process has been the increase in the percentage of funds that go to the critical technologies. If I could have number 25 please, that is a summary of what was done. For each of the 21 technologies we have the cumulative funding for the last 5 years, and the request for 1991, the appropriation for 1991, the request for 1992 and what is in the 6-year plan for each of key technologies. So, we have gone on record with the whole story here because the change from request to appropriation was the activity of the Congress, and the change from appropriation to 1992 was the activity of the Department. With a very few exceptions, you will see we have increased the funds devoted to critical technologies even over the funds that the Congress added last year. There are some deviations from that. They can all be explained, and I can provide that for the record. But the pattern is clear. We have both had an impact in the same direction.



Critical Technology Funding - Without SDI

Technology	FY 1987-91	FY 1991 Request	FY 1991 Approp	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997
1 Semiconductor Materials & Microelectronic Circuits	1729	320	437	417	418	422	423	425	445
2 Software Engineering	279	94	125	137	135	138	140	141	142
3 High Performance Computing	321	59	100	158	205	258	286	334	335
4 Machine Intelligence & Robotics	536	114	162	144	140	143	142	142	141
5 Simulation & Modelling	980	142	270	289	293	290	285	294	294
6 Photonics	663	63	164	181	185	175	174	185	168
7 Sensitive Radars	452	70	131	149	149	147	143	146	147
8 Passive Sensors	883	105	294	343	334	323	312	314	309
9 Signal & Image Processing	536	85	191	200	196	202	204	210	189
10 Signature Control (unclassified only)	464	116	116	104	97	84	82	81	83
11 Weapon System Environment	486	110	68	121	123	127	126	125	129
12 Data Fusion	337	38	94	103	106	103	93	93	88
13 Computational Fluid Dynamics	397	48	116	92	93	94	96	100	103
14 Air Breathing Propulsion	968	180	227	224	211	185	190	193	201
15 Pulsed Power	232	40	69	52	57	51	50	50	52
16 Hypervelocity Projectiles & Propulsion	212	70	49	49	55	51	50	47	46
17 High Energy Density Materials	255	46	74	70	71	75	73	76	78
18 Composite Materials	868	115	187	173	176	186	193	199	204
19 Superconductivity	286	58	54	51	46	49	49	50	52
20 Biotechnology	57	100	66	62	66	68	69	71	72
21 Flexible Manufacturing	105	17	27	25	28	29	31	32	31
Estimated Total Funding for Defense Critical Technologies S&T without SDIO	10944	1989	3081	3144	3179	3200	3211	3308	3309

Totals do not include funding for classified Signature Control efforts

$ Millions 5/1/91

These are the numbers without SDIO because SDIO presents a special case, which we can talk about if you like, but I would prefer not to get into it at this moment.

The summary of how this all comes out then is in chart 28, which shows with or without SDIO the S&T, the President's request 1991, the distribution (which is after the rescissions that have taken from 1991), the Presidential request for 1992, and then the critical technologies involved and the percentage that is critical with SDIO and without.

Critical Technology Funding
FY1991 ——→ FY1992

	FY 1991 President's Request	FY 1991 Actual	FY 1992 President's Request
S & T (with SDI)	$9.8B	$9.0B	$11.1B
Crit Tech	2.9	3.7	3.9
CT / S&T (%)	30%	41%	35%
S & T (w/o SDI)	5.3	6.2	6.0
Crit Tech	2.0	3.1	3.1
CT / S&T (%)	37%	50%	52%

The last item went from about 37 percent, which I pointed out to you last year was about the right number. The 1991 budget has 50, and we have increased that slightly to about 52. Let me say that if there are uncertainties in your mind that we may be overstating this, we are understating it in two important areas where the numbers are too sensitive to bring out. One is that NSA, for example, does a lot that is really very properly related to critical technologies, but their budget is classified. And many of the compartmented special access programs contribute to the critical technologies, but most of those numbers are classified.

So, for example, in stealth-related technologies, we have a very small number that we show in the table because those are the only unclassified numbers we could find. The real numbers are bigger. While no doubt we have overcounted some things, I know we have undercounted some things; I am pretty confident that if you put it all together, that is the right ball park. That is really where we should be steering rather than in infinite detail.

The bottom line here is that on your side of Pennsylvania Avenue and on our side we have been working the same case, and we come out with a good result. That is very gratifying to all of us, and I hope it is satisfying to you.

Let me address briefly the prioritization issue. We had the three-tier system last year. We thought about including it this year and decided that it really did not add very much to the picture. Perhaps we should have consulted with you and the staff more fully, but we felt it was not all that exciting an exercise. Instead, we did something that we thought was more creative and more insightful.

Chart 29 shows one can put the critical technologies into five major clusters. These processes are computing and information handling in general, sensing, materials and manufacturing, energy and material flow management, which is quite a mouthful, but says something that is quite important.

Defense Critical Technologies Clusters

Critical Technologies	Computing/ Information	Sensing	Materials & Manufacturing	Energy & Material Flow Management	Infra-structure
1 Semiconductor Materials & Microelectronic Circuits	●	●	●		
2 Software Engineering	●		●	●	●
3 High Performance Computing	●	●	●	●	●
4 Machine Intelligence & Robotics	●		●	●	●
5 Simulation & Modeling	●			●	●
6 Photonics	●	●			
7 Sensitive Radars	●	●			
8 Passive Sensors		●	●		
9 Signal & Image Processing	●	●			
10 Signature Control		●	●		
11 Weapon System Environment		●			●
12 Data Fusion	●				
13 Computational Fluid Dynamics	●		●	●	
14 Air Breathing Propulsion			●	●	
15 Pulsed Power			●	●	
16 Hypervelocity Projectiles & Propulsion	●		●	●	
17 High Energy Density Materials			●	●	
18 Composite Materials			●	●	
19 Superconductivity		●	●	●	
20 Biotechnology			●		
21 Flexible Manufacturing			●		●

And last but not least, infrastructure. Now, this is a way of showing that the total effort is really a seamless web that ties together many big things and a lot of little things in a way that is really very much like fabric, where every thread is connected to every other thread, except this is a 21-dimensional fabric that we have here, and to show that graphically is hopeless. But by showing these clusters, I think we have shown that there are no free-floating objects in space, if you will. It all hangs together. It is all part of an integrated program.

The place where you really see the prioritizing is on the funding chart shown previously. If you look at this chart, you will see, for example, that in 1992 we are proposing to put over $400 million in the semiconductor and microelectronic circuits category, but only $70 million into the high energy density materials because we have made the judgment, after quite a lot of thought, that there was a lot more immediate payoff and a lot more different kinds of payoff in the microelectronics area than in high energy density materials. On the other hand, high energy density materials show a lot of promise; and after consulting with a number of people, some in the national laboratories, we really came to the conclusion we have to support it at some significant level. Seventy million dollars is not a small number, but it is a lot smaller than $400 million. So, I would urge you to accept that the levels of funding are a very important indication of the priorities we put on each of these 21 things.

But you cannot cut any one out without cutting out a big piece of the fabric. It is a little bit like saying here is a human body. It has all these parts. Which part can you do without? It is tough. If it comes to that, people do make choices; but I do not think that is the way we really want to think about the program. I think we want to look at each of these, treat them on their merits, fund them in terms that assure that we have an effective program that is measured both by the capabilities and by the opportunities. So you see wide differences in the funding levels, and that is our statement of priority.

Let me comment briefly on why we have not yet addressed the issue of which organization should be in charge of which technology. As you know, the departments are undergoing a major restructuring of the laboratory and technology center complex, both under DMR and under Project Reliance. As you also know, I'm sure, we have been very much involved with the departments and the services on this.

There will be many consequences, but one is that the services' complexes will be much easier to run. They will be much easier to manage. They will be more efficiently managed. And we will get some savings that will be quite significant. My view is that some of the long-run reductions that are shown in the 6-year plan can be counted on to be arising from these savings and not from program cuts. That remains to be seen and will be watched, but that is the intention.

The second thing the services are doing in a very energetic way, much more than I have ever seen them do, is to see how they can collaborate, how they can share functions, how one service in one laboratory can do the whole job in that area for the other three services, and so on. That is Project Reliance.

It was our judgment that that process should go on another year or so before we assign institutional responsibilities for these 21 subjects. I would like the services to continue that process, to watch who really winds up being in the lead in these 21 before we say, okay, Navy, you do this or, Air Force, you do that, you're in charge of that technology and you manage that part of the complex for us. We have not seen how we could be responsive to that request without being hasty.

I am here to tell you that we have not done it. We are struggling with the problem. We are talking to the services about it, and we plan to do it. But I think we have to time it carefully so that the recipients of the responsibility are ready to take on the responsibility because we do not want to give it to them prematurely.

Let me come to the end of my comments because we have really covered the high points.

As I say, we intend to use this as our planning instrument for both managing and evaluating the program, grading the performance, and also constructing the new plans for the follow-on years. This will be a rolling document which will start as an in-house document to be used for in-house planning and in-house direction and, when it has worked its way through the Presidential budget process, will appear as a public document describing the situation as accurately as we know how. That is how this particular document was used and how the next ones will be, according to our plan. I hope what we are trying to do and how we are trying to do it are clear. We are trying to do this in a way that is responsive to both your process and our process.

Let me make a brief comment about the DOE contribution to this. First of all, I personally am very pleased with the contribution that the DOE has made to this plan. It is a very good report. As you pointed out, it is clearly the best yet. But there is a little bit more work to be done. They also found it harder than expected. We worked with them closely, perhaps not closely enough early on. That also will be improved. But I think we have two documents now that fit together fairly smoothly. The main thing that is missing now is to blend the DOE dollars smoothly into the overall dollars. That has not yet been accomplished. I think we will be able to do that relatively soon. But in terms of technical objectives, there is good concordance between the two documents, and while there may be some overlap that we have not ferreted out, by and large we are on the right track with both I believe.

And that concludes my remarks.

[The prepared statement of Dr. Herzfeld follows:]

Prepared Statement by Dr. Charles M. Herzfeld, Director Defense Research and Engineering

DOD CRITICAL TECHNOLOGIES PLAN

Mr. Chairman, members of the committee, ladies and gentlemen, I am honored to appear before you today to present this year's Defense Critical Technologies Plan and to give you an overview of the Department of Defense Science and Technology (S&T) program, that collection of programs funded by 6.1, 6.2, and 6.3a. In doing so, I hope to demonstrate how the critical technologies we have identified are becoming more instrumental each year in shaping Science and Technology plans and funding and how the Defense Critical Technologies Plan itself is evolving into an effective and far-sighted technical, management, and funding tool that is helping us chart future contributions of S&T to our national defense needs. I believe that you will be pleased with our progress so far. I look forward to even more progress in future versions.

In the recent conflict we saw the results of research and development investments of the past 20 years pay off as intended—in technological superiority on the battlefield. We also saw the confidence our fighting force had in their weapons and equipment.

The Department of Defense is making a careful analysis of the data on how our systems performed—the lessons-learned that we are all anxiously awaiting. At the same time, we need to look to the future—to the strategy and investments necessary for

— a force that can deter aggression and defeat it if deterrence fails;
— a force that uses our technological strengths to assure superiority in conflict;
— technologies and systems that we can afford to field.

President Bush said it best last August at the Aspen Institute: "To cope with the full range of challenges we may confront, we must focus on readiness and rapid response. And to prepare to meet the challenges we may face in the future, we must focus on research—an active and inventive program of defense R&D."

The Secretary of Defense, the Deputy Secretary, and the Chairman of the Joint Chiefs of Staff and others have elaborated on these remarks during this year's congressional hearings. As the Secretary of Defense stated before the full committee in February, "To preserve our unique international role, to consolidate the changes in Europe, and to contain and defeat the many possible regional threats we may one day face, we must sustain America's military forces for the new world. We must remember that military strength of the kind we have relied on in the Persian Gulf cannot be built overnight. Continued investment in America's defense is a must. . ." [Statement of the Secretary of Defense Dick Cheney before the Senate Armed Services Committee in connection with the fiscal year 1992-1993 budget for the Department of Defense, February 21, 1991]

The four elements of our new defense strategy that Secretary Cheney spoke of in his testimony (strategic deterrence and defense, a forward presence, crisis response, and force reconstitution) all demand, as he stated, "vigorous defense research and development, the fielding of advanced military systems as soon as necessary, and the preservation of critical elements of America's defense industrial and technology base."

Changes in the global situation over the past several years, including events in Eastern Europe and the earlier threats in the Persian Gulf, helped us during 1990 to produce an assessment of U.S. defense technology strategy, priorities, and investments. These have led to a broad technology strategy vision for the future.

The most recent changes in the world, mostly favorable to the United States, are setting in motion trends that we must prepare for. We must continue to be prudent in our thinking and cautious in our actions.

The following national security threats still challenge us:

(a) The dissolution of the Warsaw Pact as a military organization is transforming the military landscape of the world; but the Soviet Union continues to be a potential threat to the United States. We need to keep in mind the fact that the Soviet Union is still the only nation on earth capable of destroying the United States in one brief attack. While our national defense strategy no longer focuses primarily on Europe and the possibility of Soviet aggression there, we must not discount that nation as a formidable military force.

(b) Second, we must be prepared to deal with the rapid diffusion of lethal technologies to regional powers, including potentially unpredictable and ruthless regimes. The acquisition of modern weapons such as ballistic and cruise missiles and chemical, biological, and nuclear warheads by regimes and countries not known for cautious behavior threatens the interests of the United States and its allies in several parts of the globe.

(c) Growing, too, is the potential for low-intensity conflict, ranging from violence spawned by narcotics trafficking to terrorism to insurgencies. We must maintain and improve our technical capabilities to address these threats and, when necessary, respond effectively.

All of these factors point to the importance of a strong and stable research and development posture that is tied directly to our defense strategy, funded appropriately, and managed effectively. These were the conclusions of the Working Group on Technology that reported to the President's Commission on Integrated Long-term Strategy in 1988, described in *Discriminate Deterrence*. It is still relevant to our needs.

With this background in mind, the questions for today are as follows: Do we know where we want to go with defense technology? Are we steering in the right direction? Do we know how to get there? And do we have the resources to get there? I will attempt to give you some broad answers to these questions. You will note, as I do so, that the Defense Critical Technologies Plan plays a most significant role throughout.

First of all, we do know where we want the S&T programs within the Department of Defense to go, and we are steering our programs in the right direction, a direction that will give us the maximum appropriate use of American technology for a variety of global threats, from the strategic Soviet threat to regional conflicts to low-intensity actions. I can support this positive answer by first telling you something about our vision for defense technology and then describing our Defense Critical Technologies Plan. Formulating this vision has been one of our top priorities.

This strategic vision will be released this spring and takes a 20-year view (not too far into the future). It envisions three streams of technology; and the Defense Critical Technologies will feed all three streams.

(1) We must put in place a process that provides orderly, *evolutionary* improvements in weapon systems, their subsystems, and support systems such as the training, logistics, and defense industrial base infrastructure. These improvements must be responsive to future security threats and environments. The services are the primary agents for these evolutionary technology changes.

(2) We must put in place a process that generates innovative, highly leveraged *breakthrough* technology and inserts this technology efficiently into our military capability. Here the Defense Advanced Research Projects Agency (DARPA) is the primary agent; another is the Strategic Defense Initiative Organization (SDIO); a third is the Balanced Technology Initiative (BTI), which specializes in rapid technological insertion in responding to user pull; and last but not least, the Defense Nuclear Agency. The services, too, are pursuing some highly leveraged technologies that are appropriate for their requirements. The technologies that we think of as critical for improving weapon systems will make their major contributions as breakthrough technologies. They are likely to set the pace of innovation.

(3) Finally, we must seek *technology trump cards* (to be played every 10 years or so) to sustain long-term dominance in the technological arms race. Trump cards bring about major shifts in how we think about and conduct war. A steady generation of such trump cards will assure a strong military position for this country.

Trump cards appear unpredictably and in unexpected locations. I cannot pinpoint one focal institution or type of institution that might discover or develop a trump card as I can for evolutionary and breakthrough technologies. In addition, there is usually no military requirement for a technology trump card. Trump cards tend, instead, to come about when we have an environment that encourages discovery and invention in basic science and engineering, coupled with an environment that fosters high-level management sensitivity to the potential importance of this new science and technology.

A recent example of such a trump card is stealth aircraft, which really began with DARPA's work on the precursor to the F-117, Have Blue. Stealth has changed everyone's thinking about military air. Never again will a combat aircraft be designed without a lot of discussion about how stealthy it should be.

Other examples include the atomic bomb and the Polaris System. The Polaris System, both ships and missiles, dramatically altered the way we think about deterrence.

Certainly I expect the Defense Critical Technologies to yield future trump cards.

We need all three—evolutionary improvements, breakthrough technologies, and trump cards; and we need to manage the tech base to allow for the development and application of all three. To do so, our technology strategy must focus on several themes:

(1) When designing new systems, we must ensure maximum modularity in design and construction of platforms. We do not expect many new starts of major weapon platforms in the next 10 to 20 years, certainly not as many as we had in the 1970s and 1980s. Therefore, we must enhance the capability and longevity of the systems being developed by designing them with modular improvements in mind.

(2) We need a systematic, vigorous program to upgrade key subsystems of existing and future weapon systems, e.g., avionics, propulsion plants, weapons, communications, and countermeasures, to meet evolving threats. A great wealth of technological opportunities exist here that can give us greatly increased military capabilities. An energetic program of upgrades can make those increased capabilities more affordable.

(3) We must focus more strongly on our S&T (6.1, 6.2, and 6.3a) programs to provide the technology push for future capabilities. To achieve this, we must modernize the in-house Research, Development, Test, and Evaluation (RDT&E) establishment that supports the S&T program to make it more efficient.

(4) We must provide quality products at affordable cost by keeping the mainstream of system and subsystem developments evolutionary, while preserving opportunities for revolutionary, high-leverage improvements and their rapid introduction.

(5) We must strengthen the combination of innovation in technology and in operational concepts by identifying and demonstrating the opportunities for highly leveraged technology insertions and their interaction with operational innovations.

(6) We must radically speed up the development, introduction, and use of flexible manufacturing technology and of training technology.

(7) We must greatly increase emphasis on an integrated approach to engineering analysis, modeling and simulation, gaming, prototyping, development, test and evaluation, and net technical assessment.

One of the primary tools with which we will implement the Defense Technology Strategy is the Defense Critical Technologies Plan, which is designed to describe the technologies considered essential to maintaining the qualitative superiority of U.S. weapon systems and to outline an investment strategy to manage and promote the development of these technologies. All S&T efforts are fundamental to achieving continued improvement in military capabilities, but these critical technologies are the leading edge of the DOD Science and Technology program (see charts 1-23).

The S&T program is the principal vehicle for implementing the three streams I have described. The critical technologies focus primarily on stream two and contribute to streams one and three.

A number of Federal and private organizations are drawing up technology lists. You will note a remarkable amount of overlap and agreement between the Defense Critical Technologies Plan and the other lists that identify the technologies we need to leverage for the benefit of our Nation. I think this is a very good sign.

I am especially impressed by the recent report by the Council on Competitiveness and the critical technologies it lists.

This year's planning process was closely tied to the Technology Strategy and the 1990 plan. Each technology identified this year was selected based on its individual merits. We analyzed how each technology would contribute to improving military capabilities for a wide range of scenarios of military conflict, and we selected technologies and the technical objectives for them on the basis of maximum payoff. We used a matrix method that proceeded from identifying military objectives to basic military force packages to mission areas and then on to the critical technologies, with the technologies weighted according to their relative contributions. This is a refinement of the method used last year and was developed by members of the Joint Staff and the DDR&E Defense Critical Technologies working group. The most knowledgeable people participated at each stage, both military planners and technical experts.

Criteria were based on performance improvements for existing systems and potential for new capabilities; quality of design for availability, dependability, and reliability as well as affordability; and multiple use, including pervasiveness in major weapon systems and strengthening of the defense industrial base.

The lists prepared by the individual services, by the Joint Chiefs of Staff, and by the Defense Science Board were tremendously valuable in preparing the 1991 Defense Critical Technologies Plan. These lists are quite compatible with the Defense Critical Technologies.

Most helpful, too, were the contributions of various industry groups, including the Aerospace Industries Association (which blazed the trail in identifying critical technologies several years ago), the Electronic Industries Association, and the National Security Industrial Association. We received valuable input and comments from the Defense Science Board, the National Science Foundation, the National Aeronautics and Space Administration, and the National Institute of Standards and Technology.

Collectively the critical technologies reflect a new long-term, consistent approach to S&T by DOD, an approach that is flexible enough to adapt to both changing threats in the world and changes in technological opportunity. We must not only identify and describe the technologies, but also have a plan of action. How are we going to develop these technologies and apply them to those military systems and subsystems that will give us the highest leverage? The Defense Critical Technologies Plan gives us a means to do so.

For each of the critical technologies we have established broad technical objectives for the next 10 to 20 years as well as specific milestones for the next few years. These have been determined with detailed inputs from the services and the Defense Agencies about their technical objectives and with the help of the Defense Science Board. In addition, we have called on the directors of Defense and Department of Energy laboratories and other groups of technical experts to indicate where and when they think major, significant advances can be expected. This was most helpful, and we plan to solicit their contributions in the future. Every year we are reviewing how the technical objectives are being met by the R&D programs and will adjust future program levels based on performance and urgency of requirements.

The Defense Critical Technologies Plan is taking a major step this year toward becoming a more effective management tool because it contains far more thorough funding information. In addition to showing total planned spending levels for fiscal year 1991 as well as annual budget totals for fiscal years 1992-1997 (see charts 24 and 25), we show how these dollars are divided among the critical technologies and then show the funding for each technology by S&T Program Element (PE) for fiscal year 1991 and fiscal year 1992. One of the difficulties of managing and tracking critical technology funding is that the dollars are distributed over a large number of Program Elements. Program Elements tend to be organized around military capabilities such as advanced weapons, nuclear monitoring, and combat vehicle and automotive technology. However, the Defense Critical Technologies Plan is now helping us correlate these dollars so that we can manage them better.

Budget constraints will cause overall DOD RDT&E spending to decline over the coming years, but funding levels for Defense Critical Technologies have increased significantly in fiscal year 1992 from the fiscal year 1991 budget request and will remain stable or increase slightly from here on out (see chart 26). The Department's strong commitment to the Defense Critical Technologies is reflected in the significant growth of S&T dollars (that is, 6.1, 6.2, and 6.3a) devoted to them (see chart 27). The President's budget request for 1991 allotted 37 percent of S&T dollars (without SDI) to critical technologies. That percentage has increased to approximately 50 percent in the fiscal year 1992 request. When we include SDI in the S&T program those percentages total 28 percent for fiscal year 1991 and 35 percent for fiscal year 1992 (see chart 28). We have probably undercounted a bit because S&T also includes some programs that we did not include in our count.

The dramatic increase in the percentage of S&T dollars devoted to Defense Critical Technologies reflects DOD's determination to foster their development because of the tremendous potential they hold. These increases demonstrate the funding priority DOD places on these 21 technologies. But what of the remaining 50 percent or so of the S&T programs? Will these remaining technologies gradually wither away as the spotlight shines ever more brightly on the critical technologies? I can assure you that this will not happen, in spite of increased funding in the critical technologies arena. The remaining technologies are essential players in our strategy and plans to increase military capability. To ensure that these other technologies are given the proper attention and funding, we have begun working with the Service Acquisition Executives to determine what this remaining percentage is made up of and to identify those programs that are service-specific critical programs or essential core technologies, that we simply must fund. I see this drill as somewhat analogous to the process we have gone through in identifying the Defense Critical Technologies, formulating objectives for them, laying out milestones, and building funding for them into the total budget request. The result will be a comprehensive plan for S&T as a whole.

Turning to specifics for next year, the largest increase in the Defense Critical Technologies Plan for the fiscal year 1992 budget request is the High Performance Computing and Communications Program at DARPA. Part of the President's initiative on High Performance Computing and Communications, DARPA has increased its request in this area to $232.2 million. This increase of about $60 million is primarily for research and development on systems, network technology, and enabling software. The total DARPA investment over 6 years in this area is planned to be about $1.9 billion.

This initiative, which is being coordinated by the Federal Coordinating Council for Science, Engineering, and Technology, is a balanced program to extend our Nation's leadership in high performance computing and computer communications; to put those technologies to work for defense; and to make them an integral part of science, technology, and industry. Put simply, it seeks a thousand-fold improvement in useful, computing capability, systems that can sustain trillions of operations per second on large problems. It also seeks a hundred-fold increase in networking capability, to billions of bits per second. DARPA has been a major player in this initiative from the start.

This is an example of the sort of high-leverage breakthrough opportunity we can capture with the right guidance and resources. Another is high performance microwave tube technology, with an $8 million increase for the fiscal year 1992 request and a total of $65 million over 6 years. Applications include radar and electronic warfare and communications for land, sea, and air.

Still another example is simulation and modeling, with a request that rose from $6 million in fiscal year 1991 to $35 million in fiscal year 1992. Simulation and modeling hold out tremendous promise in expanding and improving our analytical tool box, not only within S&T but also for acquisition as a whole, for cost analysis, for training of both troops and commanders, and for planning and conducting military operations at all levels of intensity. This dollar increase is primarily for simulation for training, for close combat tactics, and for assessment of advanced weapons concepts. Each of the services has requested significant increases as well, with their funding broadly distributed in all important areas. Despite enormous technical advances in modeling and simulation, some of which served us well during the Persian Gulf conflict, we have not matched these advances with management and investments that will ensure a disciplined and uniform approach. We are now preparing a DOD plan outlining the policy, management structure, and resources required to support this simulation and simulation initiative.

Fiscal year 1992 we will have adequate resources for service-executed evolutionary technology developments. I believe these resources will be managed better because of the outcomes of Defense Management Review (DMR) 922 and laboratory consolidation.

Resources are also adequate for those breakthrough, revolutionary technologies, with DARPA taking the lead and with contributions from the services, other Defense Agencies, the Department of Energy laboratories, and industry.

Our budget is sound, although we will continuously reexamine opportunities and priorities for the fiscal year 1994 budget. The full impact of our planning will not be felt before fiscal year 1994, as we continue to evaluate our priorities during the PPBS process and increase emphasis on higher priority programs. Given the framework provided by the Defense Technology Strategy, the ability to highlight critical technologies and their clusters through the Defense Critical Technologies Plan, and the work of establishing objectives and guidelines for S&T programs, we will be able to do a better job of identifying our future needs.

In the long run, funding for Defense Critical Technologies needs to be both stable enough to reap the benefits of steady, committed investments yet flexible enough to allow for changes in threats, potential scenarios, and force structure; changes in the technologies themselves as we reassess their utility and progress; and even a few wrong turns. Technology development cannot be a risk-free enterprise. We must accept this fact.

During this year the Defense Critical Technologies Plan will become part of our input to the Defense Planning Guidance and thus will be an integral part of the Department's Planning, Programming, and Budgeting System (PPBS). We are synchronizing this and future versions of the Defense Critical Technologies Plan with DOD's management cycles, and so provide focus and guidelines to the services and the Defense Agencies as they develop their plans and investment strategies.

It is useful to note that the 21 technologies fit into five clusters (see chart 29). The clusters are an easier way of looking at a vast array of opportunities available to us. The clusters and their associated technologies are not unique, but they are useful in providing broad objectives.

— The first cluster is computing/information generation. This includes technologies that primarily involve the processing, acquisition, manipulation, synthesis, transmission, and denial of information. It forms the core of advanced C^3I, electronic warfare, target acquisition, and guidance. The strong emphasis on information in the Defense Critical Technologies Plan corresponds to the growing importance of information in modern conflict.

— The second is sensor technology. The development of "brilliant" stand-off weapons and other systems with advanced target recognition capabilities—innovations that are highly dependent upon continued progress in sensing—will become important force multipliers in the coming decades.

— The third cluster consists of materials and manufacturing processes. The addition of flexible manufacturing to the 1991 list reflects DOD's growing appreciation of the importance of this technology in the acquisition of advanced weapon systems. In particular, the development of process technology must be an integral part of overall development of product technology. Innovative process technologies are a key to reversing long-term acquisition trends toward escalating unit costs, lengthening lead times, and increasing difficulties in incorporating technological advances into systems. DARPA has a number of programs that address manufacturing processes, including their work on Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) and microelectronics manufacturing. They also provide advice on military electronics needs and a portion of the financial support to the industry consortium Semiconductor Manufacturing Technology (SEMATECH). (In addition, individual DARPA programs that focus on developing prototypes and demonstrations are now more energetically addressing the issue of how to manufacture these prototypes and demonstrations.)

— The energy and material flow management cluster includes more system-specific technologies for upgrading performance. Examples include the technologies of aircraft turbine engines, air-breathing propulsion, more lethal munitions, and high energy density materials. Pulsed power, hypervelocity projectiles, and super-conductivity also belong here.

— Fifth is a broad area of technical infrastructure. It includes such technologies as simulation and modeling, information systems, and training systems.

Note that these clusters do not set the critical technologies forth in any priority. When asked about priorities within the list, I will instead point to the clusters. All of the technologies we have identified are individually and collectively critical. Otherwise they would not be on the list. The clusters provide us with a useful way of looking at the 21 technologies. All of them need support at appropriate levels.

The Department of Energy addendum to this year's Defense Critical Technologies Plan is an order-of-magnitude improvement over past efforts to provide you with a view of how the technologies of the two departments connect. The similarity in the way we present our objectives adds to this improvement. The DOE addendum describes rather different technologies because of the differing nature of our two missions, but some overlap is evident. We have largely but not completely drawn the line in dividing our responsibilities and will do a more thorough job during the next round.

We are again providing our assessment of the relative strength of the Defense Critical Technologies in relation to the strength of our allies and of the Soviet Union in the same areas. I believe that this assessment will contribute, as well, to the national dialogue on U.S. critical technologies as a whole. Even though this assessment must by its nature be fairly imprecise, we must always be aware of potential contributions of allied and friendly nations to our collective security, just as we keep abreast of the strengths and weaknesses of potential adversaries.

Evident throughout the plan is the fact that modern military capability is largely dependent on dual-use technologies. I am pleased that awareness of this issue is growing. The resulting dialogue will be helpful in sorting out our national technological priorities. At least 15 of the 21 technologies on this year's list, in addition to contributing to vital DOD missions, have significant commercial applications or potential. Only sensitive radars, signature control, weapon system environment, pulsed power, hypervelocity projectiles, and high-energy density materials are largely unique to military applications. The predominance of dual-use technologies on our list is evident, too, when comparing various non-defense-oriented technology lists, such as the Department of Commerce list, with the Defense list.

I believe the changes we have made in this year's plan will go a long way toward making the Defense Critical Technologies Plan the sort of dynamic, results-oriented document you envisioned in your legislation. We are not there quite yet, but there has been important progress. The Department of Defense is committed to continuing this effort.

Defense Critical Technologies

1	Semiconductor Materials & Microelectronic Circuits	The production and development of ultra-small integrated electronic devices for high-speed computers, sensitive receivers, automatic control, etc.
2	Software Engineering	The generation, maintenance, and enhancement of affordable and reliable software in a timely fashion.
3	High Performance Computing	High performance computing systems having 10^3 fold improvements in computation capability and 10^2 fold improvements in communication capability by 1996.
4	Machine Intelligence & Robotics	Incorporation of aspects of human "intelligence" into computational devices which enable intelligent function of mechanical devices.
5	Simulation & Modeling	Visualization of complex processes and the testing of concepts and designs without building physical replicas.
6	Photonics	Includes ultra-low-loss fibers and optical components such as switches, couplers, and multiplexers for communications, navigation, etc.
7	Sensitive Radar	Radar sensors capable of detecting low-observable targets, or capable of non-cooperative target classification, recognition, and/or identification.
8	Passive Sensors	Sensors not needing to emit signals to detect targets, monitor the environment, or determine the status or condition of equipment.
9	Signal & Image Processing	Combination of computer architecture, algorithms, and microelectronic signal processing devices for near real-time automation of detection, classification, and tracking of targets.
10	Signature Control	The ability to control the target signature (radar, acoustic, optical, or other) and thereby enhance the survivability of vehicles and weapon systems.
11	Weapon System Environment	A detailed understanding of the natural environment (both data and models) and its influence on weapons system design and performance.
12	Data Fusion	The machine integration and/or interpretation of data and its presentation in convenient form to the human operator.
13	Computational Fluid Dynamics	The modeling of complex fluid flow to make dependable predictions by computing, thus saving time and money previously required for expensive facilities and experiments.
14	Air Breathing Propulsion	Light-weight, fuel efficient engines using atmospheric oxygen to support combustion.
15	Pulsed Power	The generation of repetitive, short-duration, high-peak power pulses with relatively light-weight, low-volume devices for weapons and sensors.
16	Hypervelocity Projectiles & Propulsion	The ability to propel projectiles to greater-than conventional velocities (over 2.0 km/sec), as well as understanding the behavior of projectiles and targets at such velocities.
17	High Energy Density Materials	Compositions of high-energy ingredients used as explosives, propellants, or pyrotechnics.
18	Composite Materials	Two or more constituent materials that are combined together in such a manner to produce a substance possessing selected properties superior to those of its individual components.
19	Superconductivity	Makes use of the zero resistance property and other unique and remarkable properties of superconductors for creation of high-performance sensors, electronic devices and subsystems, and supermagnet based systems.
20	Biotechnology	The systematic application of biology for an end use in military engineering or medicine.
21	Flexible Manufacturing	The integration of production process elements aimed at efficient, low cost operation for small, as well as high, volume part number variations, with rapidly changing requirements for end product attributes.

1. Semiconductor Materials and Microelectronic Circuits

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
1955	370	534	479	481	487	488	490	510

USSR	NATO	JAPAN	OTHERS
□	□□□	□□□□	□□ Israel

- Very large scale integrated circuits
- CAD for complex circuits
- High resolution lithography
- Analog/digital converters
- Power Converters
- Micro- and millimeter wave sources and amplifiers
- Transmit/receive modules and arrays
- Radiation hard isolation technology

2. Software Engineering

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
384	115	133	149	148	153	155	156	157

USSR	NATO	JAPAN	OTHERS
□	□□	□□	□□

- Software and system engineering processes and environments
- Real-time and fault-tolerant software
- Reuse and re-engineering
- Software for parallel and distributed heterogeneous systems
- High assurance software

3. High Performance Computing

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
414	80	108	172	219	273	301	349	350

USSR	NATO	JAPAN	OTHERS
□	□□	□□	□□ Switzerland, Israel, Hungary

- High performance computer systems
- Advanced software technology and algorithms
- High performance networking
- Basic research and human resources
- Defense specific technologies

4. Machine Intelligence and Robotics

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
551	116	162	146	142	145	144	144	143

USSR	NATO	JAPAN	OTHERS
□	□□□	□□□□	□□ Finland, Israel, Sweden

- Image understanding
- Autonomous planning
- Navigation
- Speech and text processing
- Machine learning
- Knowledge representation and acquisition
- Adaptive manipulation and control

5. Simulation and Modeling

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
1230	202	300	334	343	340	335	344	344

USSR	NATO	JAPAN	OTHERS
□□	□□□	□□□	

- Numerical solutions
- High speed graphics
- Non-linear computational problems

6. Photonics

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
710	75	167	186	190	180	179	190	173

USSR	NATO	JAPAN	OTHERS
□□	□□	□□□□	□ Various

- Laser devices
- Fiber-optics data
- Optical signal processing
- Integrated optics

7. Sensitive Radar

	FY 91	FY 91						($ M)
FY87-91	REQ.	ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
669	110	169	196	201	192	188	191	192

USSR	NATO	JAPAN	OTHERS
□□	□□□	□□□	□□ Sweden

- Advanced monostatic radar
- Multistatic radar
- Radars for non-cooperative target recognition and aided/automatic target recognition
- Phased array radar
- Laser radar
- Electronic Counter Counter Measures (ECCM)

8. Passive Sensors

	FY 91	FY 91						($ M)
FY87-91	REQ.	ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
2065	460	428	530	554	523	512	514	509

USSR	NATO	JAPAN	OTHERS
□□	□□	□□□	□ Israel

- Passive seekers
- Advanced thermal imagers/IR focal plane arrays
- Infrared search and track sensors (IRST)
- Sensor integration for target acquisition
- Advanced passive antennas
- Passive RF surveillance/electronic support measures
- Passive acoustic surveillance
- Fiber optic sensors
- Superconducting sensors

9. Signal and Image Processing

	FY 91	FY 91						($ M)
FY87-91	REQ.	ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
753	130	221	235	230	232	234	240	219

USSR	NATO	JAPAN	OTHERS
□	□□	□□	□□ Sweden, Israel

- Algorithm development
- Artificial neural networks
- Hybrid optical-digital techniques
- Control of phased arrays

10. Signature Control

	FY 91	FY 91						($ M)
FY87-91	REQ.	ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
572	120	120	109	102	89	87	86	88

USSR	NATO	JAPAN	OTHERS
□□	□□	□□	

- Radar signature (radar cross section) reduction
- Infrared, visual, and ultraviolet signature reduction
- Acoustic quieting
- Low probability of intercept radars, communications, and navigation
- Deceptive signatures (emissions and decoys)
- Magnetic silencing

11. Weapon System Environment

	FY 91	FY 91						($ M)
FY87-91	REQ.	ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
929	180	213	232	238	246	249	252	260

USSR	NATO	JAPAN	OTHERS
□□□	□□□	□□	□□ Various nations

- Ocean characterization and prediction
- Environmental characterization and prediction for local target area conditions
- Target environment analysis and scene characterization

12. Data Fusion

	FY 91	FY 91						($ M)
FY87-91	REQ.	ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
288	50	96	106	109	108	98	98	93

USSR	NATO	JAPAN	OTHERS
□	□□	□□	□□ Israel

- Theoretical foundations
- Algorithm and model development
- Data and knowledge base for fusion processing
- Development of reasoning systems
- Applications

13. Computational Fluid Dynamics

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
428	55	118	94	95	99	101	105	108

USSR	NATO	JAPAN	OTHERS
□	□□□	□□	□□ Sweden, Israel □ India, China, Australia

- Computations of unsteady aerodynamic phenomena
- Hypersonic flow solutions
- Turbulence modeling
- Internal flows
- Pre-processing (geometry and grid generation)
- Validation of CFD codes

14. Air-Breathing Propulsion

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
968	180	227	224	211	185	190	193	201

USSR	NATO	JAPAN	OTHERS
□□	□□□	□□	

IHPTET
- High-pressure ratio, lightweight, actively stabilized compression systems
- High-temperature, improved life combustion systems
- High-efficiency, high-work turbines
- Reduced signature, multi-functional nozzles
- Adaptive, survivable, high-speed integrated control systems
- High-speed, high-temperature mechanical systems
- Operationally realistic, environmentally valid technology demonstrations

Hypersonic Propulsion
- Scramjet/combined cycle technology development/demonstration
- Advanced fuels/systems for hypersonic applications

15. Pulsed Power

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
541	95	95	76	76	81	80	80	82

USSR	NATO	JAPAN	OTHERS
□□□□	□□	□□□	□□ Various Countries

- Energy storage
- Opening and closing switches
- Conditions circuits
- Prime power sources
- High power microwave

16. Hypervelocity Projectiles and Propulsion

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
710	120	153	183	205	201	200	197	196

- Projectile design
- Projectile propulsion
- Projectile - target interaction

USSR	NATO	JAPAN	OTHERS
□□□	□□	□□	

17. High Energy Density Materials

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
409	76	82	84	86	95	93	96	98

- Explosive Applications
- Propellant Applications
- High-nitrogen Atom Content Propellant & Explosive
- High-hydrogen Atom Content Propellant & Explosive

USSR	NATO	JAPAN	OTHERS
□□□	□□□	□□□	□□ China

18. Composite Materials

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	($ M) FY 97
1089	170	204	193	197	211	218	224	229

- Polymer (organic) matrix composites
- Metal matrix composites
- Carbon matrix composites
- Ceramic matrix composites
- Hybrid composites

USSR	NATO	JAPAN	OTHERS
□□	□□□	□□□	□□ Israel

19. Superconductivity

($ M)

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
345	88	58	56	51	54	54	55	57

- Low temperature superconductors
  - Supermagnetics
  - Sensors and electronics
- High temperature superconductors
  - Supermagnetics
  - Sensors and electronics

USSR	NATO	JAPAN	OTHERS
□□	□□	□□□□	□□ China Switzerland □ India Israel

20. Biotechnology

($ M)

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
79	100	69	65	66	68	69	71	72

- Processes
- Materials
- Sensors

USSR	NATO	JAPAN	OTHERS
□□	□□□	□□□□	□□ Various

21. Flexible Manufacturing

($ M)

FY87-91	FY 91 REQ.	FY 91 ACT.	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
105	17	27	25	28	29	31	32	31

- Product data definition for automated manufacturing
- CAD/CAM/CAE/CAPP
- Databases and database management
- Communications and networking
- Intelligent software interfaces

USSR	NATO	JAPAN	OTHERS
□	□□	□□	□□

LEGEND:
Position of other countries relative to the United States:

□□□□	broad technical achievement; allies capable of major contributions
□□□	moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
□□	generally lagging; allies may be capable of contributing in selected areas
□	lagging in all important aspects; allies unlikely to contribute prior to 2000

01-Mar-91

Critical Technology Funding - With SDI

Technology	FY 1987-91	FY 1991 Request	FY 1991 Approp.	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997
1 Semiconductor Materials & Microelectronic Circuits	1955	370	534	479	481	487	488	490	510
2 Software Engineering	384	115	133	149	148	153	155	156	157
3 High Performance Computing	414	80	108	172	219	273	301	349	350
4 Machine Intelligence & Robotics	551	116	162	146	142	145	144	144	143
5 Simulation & Modelling	1230	202	300	334	343	340	335	344	344
6 Photonics	710	75	167	186	190	180	179	190	173
7 Sensitive Radars	669	110	169	196	201	192	188	191	192
8 Passive Sensors	2065	460	428	530	554	523	512	514	509
9 Signal & Image Processing	753	130	221	235	230	232	234	240	219
10 Signature Control (unclassified only)	572	120	120	109	102	89	87	88	88
11 Weapon System Environment	929	180	213	232	238	246	249	252	260
12 Data Fusion	288	50	96	106	109	108	98	98	93
13 Computational Fluid Dynamics	428	55	118	94	95	99	101	105	108
14 Air Breathing Propulsion	968	180	227	224	211	185	190	193	201
15 Pulsed Power	541	95	95	76	76	81	80	80	82
16 Hypervelocity Projectiles & Propulsion	710	120	153	183	205	201	200	197	196
17 High Energy Density Materials	409	76	82	84	86	95	93	96	98
18 Composite Materials	1089	170	204	193	197	211	218	224	229
19 Superconductivity	345	88	58	56	51	54	54	55	57
20 Biotechnology	79	100	69	65	66	68	69	71	72
21 Flexible Manufacturing	105	17	27	25	28	29	31	32	31
Estimated Total Funding for Defense Critical Technologies - S&T with SDIO	15194	2909	3684	3874	3972	3991	4006	4107	4112

Totals do not include funding for classified Signature Control efforts

$ Millions

01-Mar-91

Critical Technology Funding - Without SDI

Technology	FY 1987-91	FY 1991 Request	FY 1991 Approp.	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997
1 Semiconductor Materials & Microelectronic Circuits	1729	320	497	417	418	422	423	425	445
2 Software Engineering	279	94	125	137	135	138	140	141	142
3 High Performance Computing	321	58	100	158	205	258	286	334	335
4 Machine Intelligence & Robotics	536	114	162	144	140	143	142	142	141
5 Simulation & Modelling	980	142	270	289	293	290	285	294	294
6 Photonics	663	63	164	181	185	175	174	185	168
7 Sensitive Radars	452	70	131	149	149	147	143	146	147
8 Passive Sensors	881	105	294	343	334	323	312	314	309
9 Signal & Image Processing	536	85	191	200	196	202	204	210	189
10 Signature Control (unclassified only)	464	116	116	104	97	84	82	81	83
11 Weapon System Environment	486	110	68	121	123	127	126	125	129
12 Data Fusion	237	38	94	103	106	103	93	93	88
13 Computational Fluid Dynamics	397	48	116	92	93	94	96	100	103
14 Air Breathing Propulsion	968	180	227	224	211	185	190	193	201
15 Pulsed Power	232	40	69	52	52	51	50	50	52
16 Hypervelocity Projectiles & Propulsion	212	70	49	49	55	51	50	47	46
17 High Energy Density Materials	255	46	74	70	71	75	73	76	78
18 Composite Materials	868	115	187	173	176	186	193	199	204
19 Superconductivity	286	58	54	51	46	49	49	50	52
20 Biotechnology	57	100	66	62	66	68	69	71	72
21 Flexible Manufacturing	105	17	27	25	28	29	31	32	31
Estimated Total Funding for Defense Critical Technologies - S&T without SDIO	10944	1989	3081	3144	3179	3200	3211	3308	3309

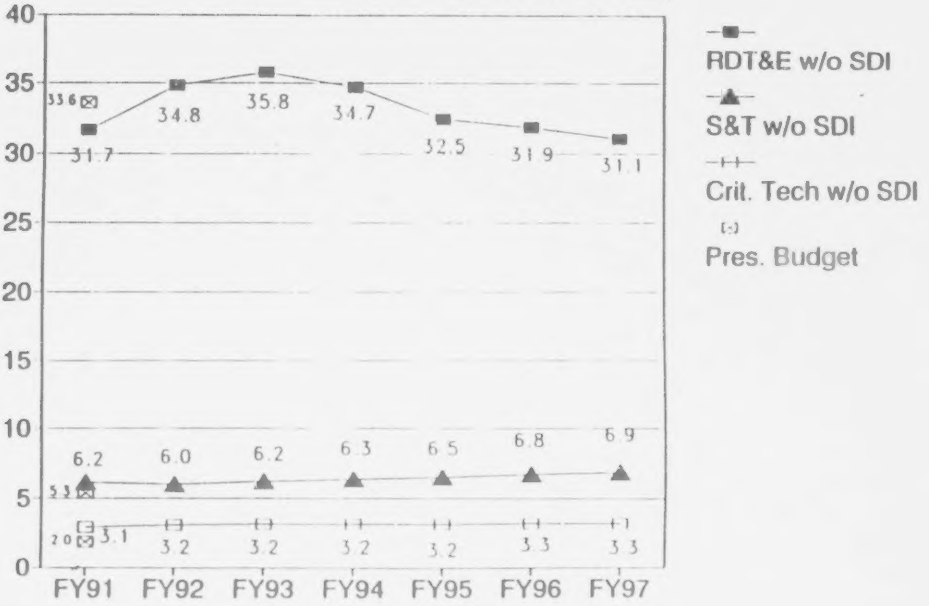
Totals do not include funding for classified Signature Control efforts

$ Millions

3/1/91

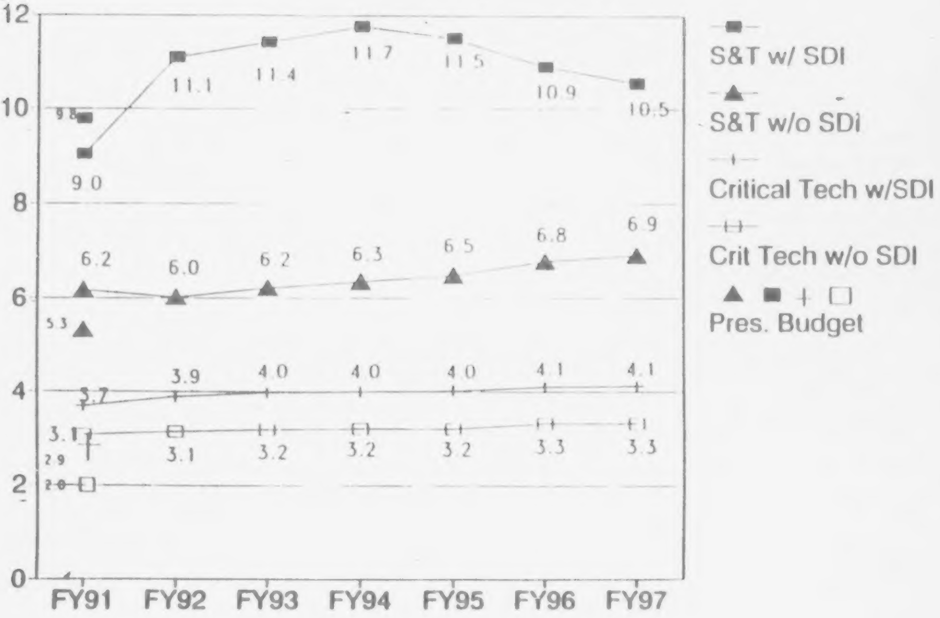
DoD RDT&E Without SDI

Current Dollar (Billions)



DoD S&T

Current $ (Billions)



Senator BINGAMAN. Thank you very much. Admiral Barr, why don't you go right ahead?

STATEMENT OF REAR ADM. J. MICHAEL BARR, U.S. NAVY, DEPUTY ASSISTANT SECRETARY FOR MILITARY APPLICATION, DEFENSE PROGRAMS OFFICE, U.S. DEPARTMENT OF ENERGY

Admiral BARR. Good morning, Mr. Chairman, Senator Smith. I am pleased to appear before you to discuss the Department of Energy Nuclear Weapons Critical Technology Annex to the Defense Critical Technologies Plan. As you mentioned earlier, with your concurrence, I will go ahead and summarize my testimony rather than reading the entire thing.

First, I would like to just briefly go over the role of the weapons laboratories. The Department of Energy has statutory responsibility for providing nuclear weapons for our national defense. To meet this requirement, our national laboratories at Los Alamos, Livermore, and at Sandia carry out research, development, and testing of nuclear weapons, and they perform the vital function of stockpile monitoring to assure continued safety, security, and effectiveness. This core mission has been the technical cornerstone of our nuclear deterrent since its inception with the Manhattan Project 45 years ago.

In addition, to support our nuclear deterrent, these laboratories engage in vital research aimed at expanding the frontiers of science and technology. They possess a unique capability in many of the technologies that are critical to maintaining U.S. superiority in nuclear and conventional weapons systems. These technologies include high performance parallel computing, highly sophisticated experimental and theoretical analysis of explosive phenomena, fabrication and analysis of unique materials, and other technologies in such fields as materials research, chemistry, nuclear physics, solid-state physics, microelectronics, mathematics, and computer science.

The ability of the laboratories to continue to support this vital research, however, is in jeopardy. Extremely tight budget constraints have affected all aspects of our programs. I am very concerned with the downward trend in the number of talented scientists and engineers working in weapons research, development, and testing. Between the start of fiscal year 1987 and the end of fiscal year 1991, there will have been a decline of nearly 30 percent in such laboratory personnel. It is important to recognize that these highly talented people are not easy to replace. It takes years to restore that loss of experience.

The erosion of the laboratory technical capability is a major concern at the Department. In recognition of this concern and the changing national priorities, the Secretary has established a task force under the Secretary of Energy Advisory Board (SEAB) to develop plans to better utilize the intellectual capital in our national laboratories. This task force will review and recommend changes in the roles and responsibilities of our laboratories while preserving the core mission of weapons research, development, and testing. During the coming year, that board will make its recommendations.

As Dr. Herzfeld mentioned, the DOE was very much involved in the preparation of the Defense Critical Technologies Plan. We believe the DOE role in that was highly appropriate. Many of the technologies that were developed for nuclear weapons science at DOE's weapons laboratories also have great potential for enhancing the capability of future DOD conventional weapons systems and, in some cases, for civilian applications as well.

Members of the Department of Energy's Defense Programs staff and representatives of all three DOE weapons laboratories participated in development of this year's Defense Critical Technologies Plan. I ought to note that this was a significant effort. There were a lot of people at the laboratories dedicated to participating in this effort.

There was one area which had not been addressed previously in the Defense Critical Technologies Plan, and that was the nuclear weapons technologies area. We and the DOD agreed that advancement of nuclear weapons technology is vital to the national defense. During last year's testimony to this committee, DOE proposed that a Nuclear Weapons Critical Technologies Annex to the Defense Critical Technologies Plan be developed. In an effort separate from the effort I was just mentioning concerning the mainline defense critical technologies plan, the Department and the national laboratories have developed this annex. It was coordinated with the DOD principally through the Defense Nuclear Agency (DNA).

The annex includes the basic elements necessary to support the Nation's nuclear deterrent, as well as nuclear fission and fusion research and development for the long-term security of the United States. The critical nuclear weapons technologies listed in the annex are derived from a larger group of 24 core technologies which are the key building blocks of nuclear weapons capability in the United States. Each of these core technologies is essential to maintaining the nuclear deterrent.

To focus on the critical technologies, those core technologies were divided into subgroups. Fifteen of these subgroups were designated as critical technologies. They were chosen because they present opportunities for significant advances in those unique capabilities needed to conduct the Department of Energy's nuclear weapons mission. It should be noted that the subgroups that were not designated critical are important and must continue to be maintained in order to assure continuing U.S. technological superiority in nuclear weapons systems.

I should point out that the way we tried to make this division and this was, as Dr. Herzfeld mentioned, a much bigger effort than I think any of us recognized to begin with. The three laboratories got together and were able to define I think for the first time in a coherent group those technologies that we really thought were key and made up the core for nuclear weapons technologies. From those extract these subgroups which you could look at as changing the most rapidly, those which if we do not keep up with them, if we do not take the lead in them, we could suffer a significant detriment to our nuclear deterrent. So, the critical technologies were really an effort to draw out those which needed special attention because of the rapidity with which they might change.

The 15 critical technologies selected span the range from nuclear weapons' predictive capability to microelectronics and photonics. In the annex, there is a discussion of the elements that compose each critical technology, the objective which the critical technology supports, the key challenges that need to be met to realize the possible significant advances. Also, key goals, payoffs, and milestones are listed for specific science and technology areas important to the critical technology. It should be noted that goals and milestones are specific to the Department of Energy. As Dr. Herzfeld noted, we tried to minimize the overlap between the annex and the rest of the critical technologies plan and emphasize those things which were DOE goals, although with a lot of those goals, there is a significant degree of commonality. The annex also contains an assessment of each technology's criticality to the national defense and, where applicable, the benefit to the U.S. economy and a discussion of foreign and domestic trends. Finally, the annex addresses obstacles to progress in those technologies.

To illustrate these features, I would like to cover one critical technology, engineered materials, in more detail.

Engineered materials are those new materials developed to satisfy specific requirements not met by existing materials or that support new or unique applications and concepts. They are designed from an understanding of fundamental scientific principles and relationships to produce specific properties.

The impetus for development of unique materials for nuclear weapons generally differs from those of commercial use, primarily because of the vastly different service environments. Although these engineered materials may be developed to meet specialized needs for nuclear weapons applications, they frequently find wider use in industrial and consumer products. Maintenance of an old and aging stockpile of nuclear weapons and ensuring its reliability depends upon an enhanced understanding of materials and on prediction of life extension technologies.

Engineered materials are the skeletal framework on which DOE nuclear weapons systems are built. Function, reliability, and safety of weapons systems require advanced materials that must perform as designed. Examples of such materials include: low-weight, high-strength alloys and composites for structural elements; organic encapsulants; wear-resistant coatings for insulators; glass-ceramics for high strength; hermetic insulator seals; materials for containment, and safe disposal of radioactive defense wastes; corrosion-resistant coatings for use in plutonium metallurgy; and advanced electronic materials such as ferro-electrics, high-field varistors, and ferrites.

Key challenges in the area of engineering materials include: developing more compact, lighter weight systems; reducing maintenance costs; developing processes and designs for improved manufacturability and waste minimization; developing materials which are stable in extreme environments; and lowering life cycle costs.

The key goals, the payoffs, and milestones in the specific science and technology areas include: ceramics and glasses, specialty metals and surface treatments. In the area of ceramics and glasses, the goals are to increase toughness and to produce thin film electronic and electro-optic ceramics. The payoffs are reduced cost and enhanced reliability. The milestones are, by about the year 2000, to increase toughness in these ceramics and glasses by a factor of 10, and to have thin films in production.

In specialty metals, another area for engineered materials, the goals are to have high-strength alloys which can withstand temperatures of 1,200 degree centigrade and to enhance manufacturability. The payoffs are lower costs and enhanced safety and reliability. The milestone is to develop alloys stable in air up to 1,200 degrees centigrade at one-tenth the current cost by the year 2000.

In surface treatments, the goal is to develop new cleaning and etching techniques. The payoff is non-carcinogenic chloride and fluoride-free cleaning and etching materials for healthier, more environmentally benign processes. The milestone is to achieve acceptable surface cleanup without environment, safety, or health concerns by the year 2000.

The criticality of engineered materials to the national defense depends on developing materials which improve performance and provide qualitative weapons superiority while minimizing hazardous waste generation and reducing costs. These same features, improved performance while minimizing waste and reducing costs, could also have civilian sector applications.

Engineered materials are receiving increased attention in foreign countries. Our effort is hampered by a lack of integrated industrial and DOE efforts in materials science and engineering. In this area, we think aggressive technology transfer could help.

That is just going over one of the areas very, very briefly. What I wanted to do with that was to show you that there is a broad range in each of these technologies, and we are very interested not only in the technology itself, but also in the adjunct areas such as waste minimization and environment, safety, and health to be sure that we are covering in a balanced way all the things that affect those specific critical technology areas.

I could give a similar account for each of the critical technologies, but I will limit this discussion to presenting just a few highlights of some of the other critical technologies and their payoffs.

Nuclear weapons predictive capability is essential for making confident assessments of nuclear weapons performance under varying circumstances. By improving our knowledge of materials, both nuclear and non-nuclear, hydrodynamics, radiation transport, and by employing substantially increased computer power, our ability to predict weapons performance will be greatly improved. As a result, we will be better able to retain nuclear competence if we face reduced levels of testing and development.

Microelectronics and photonics improvements will provide the building blocks for ultra-smart weapons with broad mission flexibility, automated target recognition, sensors and signal processors for safe weapons transportation and storage, as well as the possibility of technology transfer to the threatened U.S. electronics industry. Specialized DOE needs include tolerance to extremely high levels of ionizing radiation from fratricide or defensive nuclear weapons and the extreme environmental conditions of nuclear weapons storage and delivery.

Enhanced nuclear weapons test diagnostic capabilities will allow us to extract the most data from each nuclear test so that we may understand the detailed behavior of nuclear weapons systems better.

Improved manufacturing and processing techniques, including robotics, will lead to increased production efficiency, reduced worker radiation exposure, a smaller, less expensive, more flexible production complex, reduced waste streams, and the potential for commercial spinoffs.

Research and implementation of advanced surety concepts including using fire-resistant materials, insensitive high explosives (IHE), and electronic and photonic devices will allow progress toward the goal of inherent weapons safety, more flexibility in basing and deployment options, improved use control, and individual weapon accountability.

Pulsed reactors and critical assemblies are a very specialized class of facilities. These are essential to validate nuclear weapons safety calculations, in processing facility designs, and to generate data for the civil power sector.

And finally, advances in hardware and software for scientific and engineering computing will lead to advances in nuclear weapons design and other defense technology modeling, engineering and scientific simulations, computer integrated manufacturing, and intelligent system control.

In summary, I believe the Department has made a good start on the process of focusing on the critical nuclear weapons technologies although, as you pointed out, Mr. Chairman, and as Dr. Herzfeld has, we recognize we have a long way to go. This is a start, the first year, and we think we can carry on with it and really get something very beneficial out of this effort.

Clearly, it is going to be an ongoing process which will require further effort in the outyears to successfully execute a consistent program. I want to emphasize that the execution of such a program relies on a strong national defense science and technology capability, particularly at our weapons laboratories. Regardless of the future direction of international realignments, we must preserve our ability to guard against technological surprise, continue to assess potential threats, be prepared to respond to deterrent requirements for new nuclear weapons, provide enhanced weapons safety and security, develop means to verify potential future arms control treaties and, where feasible, transfer useful technologies to the private sector.

Thank you, Mr. Chairman.

[The prepared statement of Admiral Barr follows:]

Prepared Statement by Rear Adm. J.M. Barr, USN, Deputy Assistant Secretary for Military Application, U.S. Department of Energy

INTRODUCTION

Good morning Mr. Chairman and members of the subcommittee. I am Rear Adm. Mike Barr, Deputy Assistant Secretary for Military Application. I am pleased to appear before you today to discuss the Department of Energy's Nuclear Weapons Critical Technology Annex.

ROLE OF THE WEAPONS LABORATORIES

The Department of Energy's Defense Program has the statutory responsibility for providing nuclear weapons for our national defense. To meet this requirement, our National Laboratories at Los Alamos, Lawrence Livermore, and Sandia carry out research, development, and testing of nuclear weapons and perform the vital function of stockpile monitoring to assure continued safety, security and effectiveness. This core mission has been the technical cornerstone of our nuclear deterrent since its inception with the Manhattan Project over 45 years ago.

In addition, to support our nuclear deterrent, these laboratories engage in vital research aimed at expanding the frontiers of science and technology. They possess a unique capability in many of the technologies that are critical to maintaining U.S. superiority in nuclear and conventional weapons systems. The technologies include high performance parallel computation, highly sophisticated experimental and theoretical analysis of explosive phenomena, fabrication and analysis of unique materials, and other technologies in such fields as materials research, chemistry, nuclear physics, solid-state physics, microelectronics, mathematics, and computer science.

The ability of the laboratories to continue to support vital research is in jeopardy. Extremely tight budgetary constraints have affected all aspects of our programs. As a result, I am very concerned with the downward trend in the number of talented scientists and engineers working in weapons research, development, and testing. Between the start of fiscal year 1987 and the end of fiscal year 1991, there will be a decline of nearly 30 percent in such laboratory personnel. In fiscal year 1991, as part of this decline, the weapons program staff is expected to fall by 6 percent, resulting in the loss of approximately 500 additional positions. It is important to recognize that these highly talented people are not easy to replace—it takes years to restore the loss of experience.

The erosion of laboratory technical capability is a major concern to the Department. In recognition of this concern and changing national priorities, the Secretary established a task force under the Secretary of Energy Advisory Board to develop plans to better utilize the intellectual capital in our national laboratories. This task force will review and recommend changes in the roles and responsibilities of these laboratories, while preserving the core mission of weapons research, development, and testing. During the coming year, the Board will make its recommendations.

DOE'S ROLE IN THE DEFENSE CRITICAL TECHNOLOGIES PLAN

Public Law 101-189 (November 29, 1989) and Public Law 101-510 (November 5, 1990) directed that the Secretary of Defense, in consultation with the Secretary of Energy, submit to the Armed Services Committees an annual plan for developing the technologies most critical to ensuring the long term qualitative superiority of U.S. weapons systems. We believe the DOE role to be highly appropriate because many of the technologies developed for nuclear weapons science at DOE's weapons laboratories also have great potential for enhancing the capabilities of future DOD conventional weapons systems as well as for civilian applications.

The plan is an important instrument in identifying the defense technologies which represent significant opportunities for advancing our national defense. We have worked closely with the Department of Defense in the preparation of this plan. From the fall of 1990 through the end of February 1991, members of the Department's Defense Programs staff and representatives of the three DOE weapons laboratories participated in the 1991 Defense Critical Technology Plan Working Group composed largely of DOD agency and service representatives and chaired by a representative of the DOD's Director of Defense Research and Engineering.

In parallel, DOE staff and another team of DOE weapons laboratory representatives began a separate effort to identify the nuclear weapons technologies which DOE believes to be critical for making significant advances in those unique capabilities needed to conduct the DOE nuclear weapons mission and to maintain U.S. nuclear weapons technological superiority. Coordination with DOD was achieved through the Defense Nuclear Agency.

Nuclear weapons technologies had not been included in earlier versions of the Defense Critical Technologies Plan. DOE and DOD agreed that advancement of nuclear weapons technologies is vital to the national defense. During last year's testimony to this committee, DOE proposed that a Nuclear Weapons Critical Technologies (NWCT) Annex to the Defense Critical Technologies Plan be developed. Since that time, the Department and the National Laboratories have been developing this Annex.

This is the first Nuclear Weapons Critical Technologies Annex, and I believe that it is the most comprehensive document on this subject ever assembled. It describes not only the nuclear weapons core technologies needed to maintain our present nuclear weapons capability, but also the subsets which present critical opportunities for the United States in making important advances in nuclear weapons capabilities in the future.

The annex includes the basic elements necessary to support the Nation's nuclear deterrent, as well as nuclear fission and fusion research and development for the long term security of the United States. The critical nuclear weapons technologies listed in this annex are derived from a larger group of 24 core technologies (Attachment 1) which are the key building blocks of nuclear weapons capability in the United States. Each of these technologies is essential to maintaining a nuclear deterrent. Those core technologies have been further divided into subgroups. Fifteen of these subgroups were designated as critical technologies (Attachment 2). These critical technologies were chosen because they present opportunities for significant advances in those unique capabilities needed to conduct the Department of Energy nuclear weapons mission. The subgroups not designated critical are important, and must continue to be maintained in order to assure continuing U.S. technological superiority in nuclear weapons systems. In many cases, the National Weapons Laboratories-Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and Sandia National Laboratory (SNL)—are the sole source of specific technological capabilities necessary for development of certain weapons components and systems.

The 15 critical technologies span the range from nuclear weapons predictive capability to microelectronics and photonics. In each case, there is a discussion of the elements that compose the critical technology, the objectives which the critical technology supports, and key challenges that need to be met to realize the possible significant advances. Also, key goals, payoffs, and milestones are discussed. It should be noted that the goals and milestones are specific to the Department of Energy. Even where there is overlap with the Department of Defense in a critical technology, the DOE's goals are usually different from DOD's. The report contains an assessment of each technology's criticality to national defense, and where applicable the benefit to the U.S. economy and a discussion of domestic and foreign trends. Finally the report addresses obstacles to progress.

To illustrate these features, I will cover one critical technology, engineered materials, in more detail.

Engineered materials are those new materials developed to satisfy specific property requirements not met by existing materials, that support new or unique applications and concepts. They are designed from an understanding of fundamental scientific principals and relationships to produce specific properties.

The impetus for development of unique materials for-nuclear weapons generally differs from those of commercial use primarily because of vastly different service environments. Although these engineered materials may be developed to meet specialized needs for nuclear weapons applications, they frequently find wider use in industrial and consumer products. Maintenance of an old and aging stockpile of nuclear weapons and ensuring its reliability depend critically on an enhanced understanding of materials and prediction/life extension technologies.

Engineered materials are the skeletal framework on which DOE nuclear weapon systems are built. Function, reliability; and safety of weapon systems require advanced materials that must perform as designed. Examples of such materials include low-weight, high strength alloys and composites for structural elements, organic encapsulants, wear-resistant coatings for insulators, glasses, and glass ceramics for high-strength, hermetic-insulator seals, materials for containment and safe disposal of radioactive defense wastes, corrosion-resistant coating for use in plutonium metallurgy/handling, and advanced electronic materials such as ferro-electrics, high-field varistors, and ferrites.

A recent study by the National Research Council summarized the importance of the technology by saying "Materials science and engineering (and by extension, engineered materials) is crucial to the success of industries that are important to the strength of the U.S. economy and U.S. defense." (Ref: Materials Science and Engineering for the 1990's, National Academy Press, Washington, DC, 1989, p. 3).

A similar account could be given for each of the critical technologies, but I will limit this discussion to presenting a few highlights of some other critical technologies and their payoffs:

— Nuclear weapons predictive capability is essential for making confident assessments. By improving our knowledge of materials, both nuclear and nonnuclear, hydrodynamics, radiation transport, and employing substantially increased computational power, our ability to predict weapons performance will be greatly improved. As a result we will be better able to retain nuclear competence if we must face reduced levels of testing and development.

—Microelectronics and photonic improvements will provide the building blocks for ultra-smart weapons with broad mission flexibility, automated target recognition, sensors and signal processors for safe weapons transportation and storage, as well as the possibility of technology transfer to the threatened U.S. electronics industry. Specialized DOE needs include tolerance to extremely high levels of ionizing radiation from fratricide or defensive nuclear weapons and the extreme environmental conditions of nuclear weapons stockpile and delivery.

— Enhanced nuclear weapons,test diagnostic capabilities will allow us to extract the most data from each nuclear test so that we can understand the detailed behavior of nuclear weapons systems.

— Improved manufacturing and processing techniques (including robotics) for nuclear materials will lead to: increased production efficiency; reduced worker exposure; a smaller, less expensive, more flexible production complex; reduced waste streams; and the potential for commercial spinoffs.

— Research and implementation of advanced surety concepts including using fire resistant materials, insensitive high explosives, electronic and photonic devices will allow progress toward the goal of inherently safe weapons, more flexibility in basing and deployment options, improved use control and individual weapon accountability.

— Pulsed reactors and critical assemblies are a very specialized class of facilities. They are essential to validate weapons safety calculations, processing facility design, and generate data for the civil power sector. We must maintain the only facilities of this kind left in the United States.

— DOE plays a special role in developing specialized instrumentation for monitoring treaties—satellite sensors, field instruments, nuclear test, maintaining equipment, etc. Our laboratory analysts provide modeling expertise for the entire intelligence community in foreign nuclear weapon assessment. DOE developed safeguards are the backbone of the international materials control community.

— Advances in hardware and software for scientific and engineering computing will lead to advances in nuclear weapons design and other defense technology modeling, engineering and scientific simulations, computer integrated manufacturing, and intelligent system control.

SUMMARY

In summary, I believe that the Department has made a good start on the process of focussing on the critical nuclear weapons technologies. Clearly this is the beginning of an ongoing process which will require further effort in the outyears to successfully execute a consistent program. I want to emphasize that the execution of such a program relies on a strong national defense science and technology capability, particularly at the weapons laboratories. Regardless of the future direction of international realignments, we must preserve our ability to guard against technological surprise, continue to assess potential threats, be prepared to respond to deterrent requirements for new nuclear weapons, provide enhanced weapons safety and security, develop means to verify potential future arms control treaties, and where feasible, transfer useful technologies to the private sector.

DEFINITIONS

The following definitions apply to the material covered in this annex:

Capabilities and Facilities—The expertise in key scientific and engineering disciplines, the core technologies, and unique laboratory and experimental facilities that allow expeditious execution of programs.

Core Technology—A group of enabling technologies and expert competencies unique to the requirements of the nuclear weapons program that are the key building blocks of nuclear weapons research, development, and testing, and that are proceeding along an evolutionary path to maintain United States nuclear weapons capabilities.

Critical Technology—Those subgroups of the core technologies whose challenges present significant opportunities for revolutionary advances in those unique capabilities needed to conduct the Department of Energy nuclear weapons mission and to maintain United States nuclear weapons technology superiority.

Program—The orchestration of core technologies, expert competencies, capabilities, facilities, and resources to carry out a mission.

Attachment #1

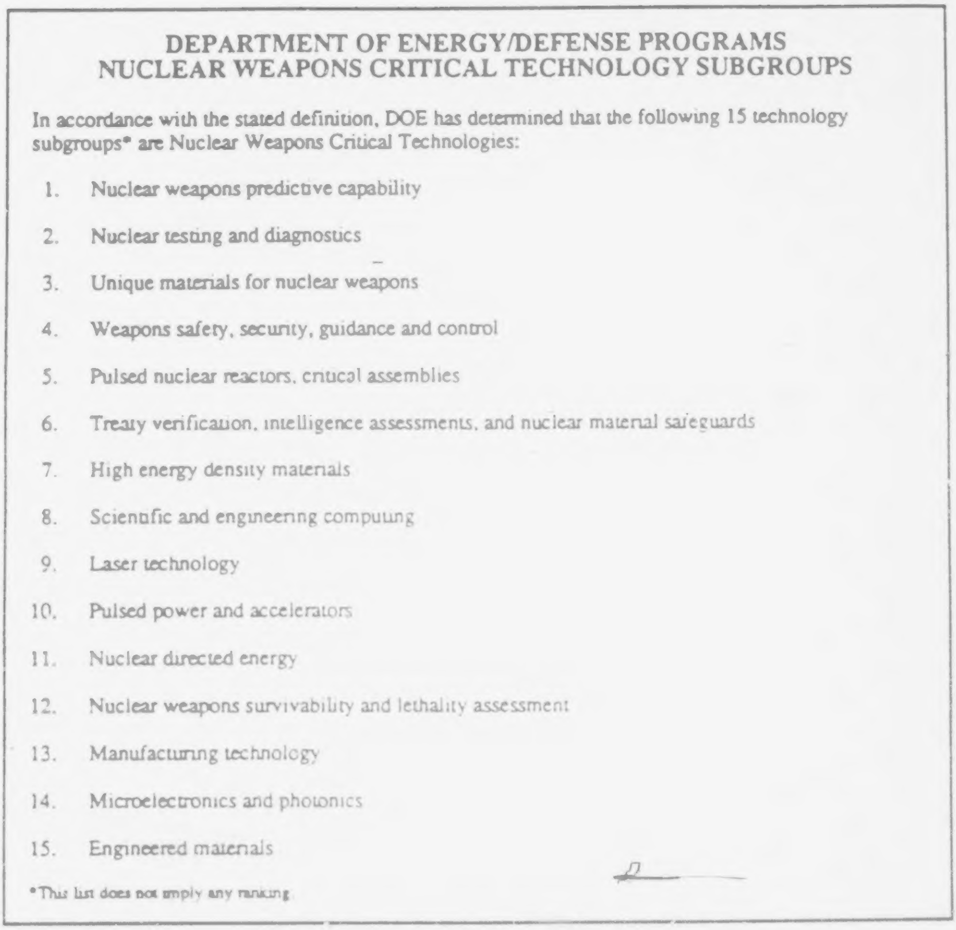
DEPARTMENT OF ENERGY/DEFENSE PROGRAMS
NUCLEAR WEAPONS CORE TECHNOLOGY GROUPS

In accordance with the stated definition, the Department of Energy has determined that the following 24 technology groups* are Nuclear Weapons Core Technologies:

1. Nuclear weapons design technology
2. Nuclear weapons testing technology (underground and above ground)
3. Nuclear materials development technology
4. Nuclear weapons engineering technology
5. Nuclear weapons safety and security technology
6. Nuclear weapons effects and simulation technology
7. Nuclear weapons data bases technology
8. Nuclear weapons verification, safeguards, and intelligence technology
9. Weapons primary explosives technology
10. Fusion simulation via inertial confinement technology
11. Nuclear directed energy weapons technology
12. Nuclear device vulnerability, lethality and hardening technology
13. Nuclear weapons safe, arming, firing, and fuzing technology
14. Nuclear weapons delivery technology
15. Environment, safety and health technology
16. Nuclear weapons material technology
17. Nuclear power sources technology
18. Computational sciences technology for weapons performance simulation
19. Nuclear criticality technology
20. Pulsed power conversion technology for weapons effects
21. Radiochemistry technology
22. Accelerator technology for weapons physics studies
23. Microelectronics and photonics technology for weapons arming, fuzing, and firing
24. Nuclear weapons manufacturing technology

*This list does not imply any ranking.

Attachment #2



DEPARTMENT OF ENERGY/DEFENSE PROGRAMS
NUCLEAR WEAPONS CRITICAL TECHNOLOGY SUBGROUPS

In accordance with the stated definition, DOE has determined that the following 15 technology subgroups* are Nuclear Weapons Critical Technologies:

1. Nuclear weapons predictive capability
2. Nuclear testing and diagnostics
3. Unique materials for nuclear weapons
4. Weapons safety, security, guidance and control
5. Pulsed nuclear reactors, critical assemblies
6. Treaty verification, intelligence assessments, and nuclear material safeguards
7. High energy density materials
8. Scientific and engineering computing
9. Laser technology
10. Pulsed power and accelerators
11. Nuclear directed energy
12. Nuclear weapons survivability and lethality assessment
13. Manufacturing technology
14. Microelectronics and photonics
15. Engineered materials

*This list does not imply any ranking

Senator **Bingaman**. Thank you very much.

Mr. Swihart, why don't you go right ahead before we have questions.

STATEMENT OF JOHN M. SWIHART, PRESIDENT, NATIONAL CENTER FOR ADVANCED TECHNOLOGIES

Mr. **Swihart**. Mr. Chairman and members of the subcommittee, on behalf of the Aerospace Industries Association, AIA, and the National Center for Advanced Technologies, NCAT, we thank you for the opportunity to appear before you today to discuss industry's role in moving forward to strengthen our current technology base. You have indicated that the written testimony will be part of the record, and I would like to summarize that for you.

Mr. **Swihart**. My name is John Swihart. I am the President of NCAT, a nonprofit foundation of the AIA. Prior to the formation of NCAT, I retired as corporate vice president of the Boeing Company with over 26 years of service. Before that, I worked at NASA's

Langley Research Center for 13 years, and both there and at Boeing I was involved with the evolution of aerospace technology.

AIA, as you all know, represents 57 of the Nation's major manufacturers of commercial, military, and business aircraft, helicopters, aircraft engines, missiles, spacecrafts, and related components and equipment.

We in the aerospace industry are deeply concerned about America's industrial competitiveness. We started a program, as the Chairman mentioned, in 1986 to improve the situation before it was too late. NCAT and AIA sponsored the development of a new approach, the Key Technologies For The Year 2000. This program seeks to develop national strategic plans for the maturity of these key technologies by a national cooperative program led by industry with government and academia as equal partners. The schedule for completion of the detailed strategic plans for our 11 key technologies is contained in the written testimony, as well as the names of the industry sponsors for each one.

By bringing the technologies to maturity on our accelerated schedule and applying them to world-class products ahead of our competitors, the U.S. economy, the balance of trade, and the security will gain enormously. These benefits will extend beyond aerospace because the technologies are generally dual-use and applicable to commercial as well as defense products.

NCAT has been in operation since 1989, and has provided vital technical guidance to both government agencies and industry participants. Dr. Herzfeld mentioned how we have worked with him now for 3 years on working the critical technologies plan. The key technologies road maps have been reviewed and received by DOD for both the Defense Critical Technologies Plan submitted to the Congress and the most recent one, which we just got last night. They have also been received and reviewed by the Department of Commerce, NASA, the Council on Competitiveness, and the White House Office of Science and Technology Policy.

The aerospace industry participants who have provided both the financial investment and the voluntary technical expertise have significantly benefited from the NCAT program. A recent survey revealed that the percentage of technology funding in company internal research and development programs has been 40 percent in the key technologies from 1988 through 1991. This says that the AIA companies place a high value on our plans and have invested their capital accordingly. I know from personal contact that others in academia and the government labs also find the plans very useful. I would add that more than 1,000 people have participated in the development of each of our strategic plans to date, but the problem is not lists and not plans because we have a good consensus between everyone, DOC, DOD, OSTP, as to what is on the proper list. The problem is future funding levels.

I had a brief look at the DOD critical technologies report for this year last night and can say that even though the request for 1992 is up, the outyears do not keep up with inflation. I believe that the program for a technology base should be stable to slightly increasing, including the effect of inflation. So, this could be considered to be slightly inadequate.

Current projections show that the sum of defense development and procurement will decline by about 30 percent by the year 2000. That means that the technology base and the base for IR&D reimbursement will decrease. The net result will be a lower level of research and advanced development. This lower level is not acceptable to a continued strong U.S. economic system, nor to a strong U.S. national defense. If we are having trouble competing in the international marketplace now when we are the acknowledged leaders in many of the technology developments, what will our position be when we are one among many leading edge technology developers?

I believe it is imperative that we not let this happen. I urge this committee and others who share your responsibility with respect to DOD funding to insist on an adequate level of funding for defense technology and the associated industry IR&D. Stable and slightly increasing funding above the inflation level is required if we are to maintain a strong base of technology to fuel a strong, healthy and competitive United States industry.

Thank you very much.

[The prepared statement of Mr. Swihart follows:]

Prepared Testimony by John M. Swihart, Aerospace Industries Association of America, Inc. and The National Center for Advanced Technologies, Inc.

Mr. Chairman and members of the subcommittee: On behalf of the Aerospace Industries Association (AIA) and the National Center for Advanced Technologies (NCAT), we thank you for this opportunity to appear before you today to discuss industry's role in moving forward to strengthen our current technology base. We are proud of our Armed Forces in the Gulf War as we speak to you today. We are especially proud of the key role that our companies played in creating and bringing to fruition the technologies that helped to bring the war to a swift and decisive conclusion.

My name is John Swihart. I am the President of the National Center for Advanced Technologies (NCAT), a non-profit foundation formed by the Aerospace Industries Association of America (AIA). Prior to my association with NCAT, I retired as a corporate vice president of the Boeing Company with over 25 years of service. Before that I worked at NASA for 13 years and both there and at Boeing I was involved with the evolution of aerospace technology. ALA represents 57 of the Nation's major manufacturers of commercial, military and business aircraft, helicopters, aircraft engines, missiles, spacecrafts, and related components and equipment.

We in the aerospace industry are deeply concerned about American industrial competitiveness. We have been concerned about the inadequacies of our R&D for some time and several years ago began a program to improve the situation before it was too late. NCAT/AIA sponsored the development of a new approach, the key technologies for the year 2000. It seeks to make the expensive process of technology development more affordable by taking advantage of the efficiencies inherent in a national cooperative program involving not only interested industrial concerns, but also government laboratories and universities.

This program currently focuses on the development of 11 key technologies selected by NCAT/AIA on the basis of highest leverage, greatest potential payoff and broadest applicability to both civil and military products. Each key technology should be afforded priority and developed on an accelerated basis as a national initiative of industry, government and academia, each contributing its special capabilities in a closely coordinated team effort.

By bringing these technologies to maturity on an accelerated schedule and applying them to advanced products ahead of our competitors, the United States will gain enormous benefit not only in trade but in national security capability. Because of the broad applicability of the technologies selected, the benefits will extend beyond the aerospace/defense sector to many other American industries. All of the technologies are dual-use and applicable to both military and commercial products.

Our current schedule for completing the NCAT/AIA key technologies road maps and plans is given in figure 1. Some delays are inherent in a program that depends on voluntary cooperation and performance, but we have been able to maintain a fairly good record. We hope to have all the plans ready by the end of summer with the exception of advanced metallic structures and computational sciences which were stated later than the others (advanced metallic structures was added only last November). Superconductivity may also be later than we would like because of personnel changes at the sponsoring company.

This entire effort is led by the industry, and figure 2 lists the sponsors and companies for the 11 key technologies. In addition to the technologists, each company also provides a member from its manufacturing organization to work with the team developing the plans.

Under the guidance of NCAT/AIA, the objective is to make the technology development and integration process substantially more efficient than the traditional method. Industry, universities, and government function as partners in a coordinated team, each contributing to the generic technology bank from basic research through technology development—thus avoiding costly duplication and reducing risk before any attempt is made to apply the technology to a product. This precompetitive cooperation avoids unwarranted duplication of effort and provides a broader technology base in key areas.

When a technology reaches a "reasonable risk" state of maturity, industry participants will individually pursue their own product developments in a competitive environment. Similarly, government agencies will determine which applications are important to their missions and proceed accordingly.

NCAT/AIA believes that the national technology development approach will effect a 2-to-1 increase in the productivity of available resources and cut in half the time it takes to develop and field technology. Most importantly, this program aims to make available—before the turn of the century—the technological tools American industry needs to compete more effectively.

NCAT, an industry-led effort, sponsored through the AIA membership, has been in operation since 1989 and has provided vital technical guidance to both government agencies and its own industry participants. The key technology road maps have been received and reviewed by the Department of Defense (DOD), for both of the defense critical technologies plans submitted to Congress. They have also been received and reviewed by the Department of Commerce, NASA, the Council on Competitiveness, and the White House Office of Science and Technology Policy.

The aerospace industry participants who have provided both the financial investment and voluntary technical expertise in this program have significantly benefited from the NCAT/AIA program. In a survey of company internal R&D programs by AIA members, it was found that the percentage of technology funding invested in the key technologies has been approximately 40 percent from 1988 to 1990. This continued interest shows that not only is industry participating in the AIA/NCAT program, they have placed a high value on the content of the road maps and technology development plans received and invested their capital accordingly.

We have received evidence that others find the plans valuable. Recently I addressed a conference of the National Academy of Engineering at the University of California at Irvine and Dr. Frank Marble, a professor from Cal Tech, volunteered in the question and answer session that he had used the Rocket Propulsion Plan to get his research budget increased. From the interest being generated and the requests for road maps and plans following each public appearance, I believe there is great interest in our efforts.

There are two fundamental aspects of our process that make it unique. First, it is led by industry with full and equal participation by government and academia. Second, the Strategic Technology Development Plans represent a true national consensus in that several hundred experts contribute to the final version either as direct participants or as reviewers. I know of no other technology plans that have that breadth of participation; further, no one else has developed details rather than recommendations. The cooperative efforts also mean that the plans when published have a broad and effective constituency to hasten effective implementation. The industry participants urge the inclusion of the plan in their company's IR&D program, the government laboratory participants urge it on their superiors, and I have already commented on one academician's use of the plan. More and more technology is becoming less specific in its application, and DOD-developed technology is more and more dual-use—that is it leads to important civilian commercial applications. Thus, just as DOD is being urged to use more COTS—commercial off-the-shelf—technology, the newest military technologies are more and more applicable to wider use.

Comparisons of the overlap between the Key Technologies of the AIA, the Critical Technologies of the DOD, the Emerging Technologies of the Department of Commerce, and the National Critical Technologies of OSTP show that there is substantial agreement. NCAT is working in four of the six areas defined by OSTP in its list of National Critical Technologies, and in 10 of the 22 technologies. In all, we cover two thirds of the DOD list, two thirds of the DOC list, and one half of the OSTP list. This degree of agreement is not surprising, especially since one of our selection criteria was multiple use.

The Department of Defense Critical Technologies Plan for 1991 was not received in time for us to review it. Based on our previous cooperation with DOD, I would expect the plan to incorporate a significant fraction of inputs received from the review of last year's plan produced by three industry trade associations: the Aerospace Industries Association, the Electronic Industries Association, and the National Security Industrial Association. That review included for the first time specific suggestions for the current plan.

The degree of cooperation between the DOD and the three trade associations has been excellent. The industry has been invited and has participated in several meetings and conferences; in addition we have provided written drafts and final versions of the NCAT/AIA road maps and strategic technology development plans to the DOD.

We reached agreement with the DOD for interactive cooperation on five of the critical technologies: optical information processing, air-breathing propulsion, superconductivity, advanced composites, and advanced sensors.

Figure 3 shows the associations which led the industry reviews of the DOD Critical Technologies Plans. As I mentioned earlier, in 1990, we also submitted specific suggestions to DOD for their current plan.

As observed by the Council on Competitiveness at the release of their report "Gaining New Ground", there is no need for more lists. Now it is time to do something with the lists that exist—there is no need for an "ultimate list". The next step is to work cooperatively to develop detailed development plans, particularly for those technologies that are common to all the lists. That is exactly what NCAT has done. The process that has been developed and demonstrated within the aerospace industry is applicable to other industries, and we are very interested in expediting these applications. Thus, we have scheduled a major policy symposium in Washington, D.C. for September 5 and 6 of this year to reach and involve a broader audience. We are contacting other trade and industrial associations as well as professional societies to increase participation and to extend the process.

We believe our efforts are unique and represent an ideal melding of the strongest economic system yet developed—the free enterprise system—with industry, government, and universities cooperating as equal partners.

Let me turn now to what is probably the most serious problem facing technology development in our country. That is the projected level of total spending for technology in the next 10 years. I do not mean government spending alone, although that is a very substantial part of the funding of the total R&D spending in 1989 ($142 billion), the industry performed about two thirds ($103 billion) and funded two thirds of that ($69 billion).

Current projections show that the sum of defense development and procurement will decline by about 30 percent by the year 2000. That means the technology base and the base for IR&D reimbursement will decrease. The net result will be a level of research and advanced development much lower than the current level. Since much if not most defense-related R&D is also usable in the commercial market, the future for technology in the United States will incur a downward trend. We already have difficulty in applying the technology developed here before our foreign competitors do, and if these forecasts prevail we will soon lose our competitive posture.

The final result is not acceptable to a continued strong U.S. economic system, nor to a strong U.S. national defense.

In the arena of technology, there is probably no other threat that approaches this one in magnitude or danger. If we are having troubles competing in the international market place now when we are the acknowledged world leaders in technology development, what will our position be when we are only one of many leading-edge technology developers? How prepared will our Nation and its military be before the next unexpected military crisis? Clearly we face a potential catastrophe.

I believe it is imperative that these forecasts not come to pass. I urge this committee and others who share your responsibility with respect to DOD funding to insist on an adequate level of funding for defense technology and the associated industry independent research and development. Stable and slightly increasing funding is required if we are to maintain a strong base of technology to provide the basis for a strong, healthy, competitive U.S. industry.

NCAT SCHEDULE FOR ROAD MAPS AND PLANS

Key Technology	Road Map	Tech. Strategic Plan (Draft)
Advanced Composites	June 1989	December 1990
Adv. Metallic Struct.	June 1991	1992
Advanced Sensors	March 1989	June 1990
Air-Breath. Prop.	March 1989	June 1991
Artificial Intell.	June 1989	June 1991
Computational Science	July 1991	1992
Optical Info. Process	June 1989	June 1991
Rocket Propulsion	November 1988	August 1989
Software Development	March 1989	June 1991
Superconductivity	August 1991	1992
Ultrarel. Elect. Sys.	March 1990	August 1991

Figure 1

NCAT KEY TECHNOLOGIES
For the Year 2000

TECHNOLOGY	SPONSOR	COMPANY
Advanced Composites	F. W. FENTER	LTV
Acv. Metallic Struct.	W. S. CEBULAK	ALCOA
Advanced Sensors	R. N. LONGUEMARE	WESTINGHOUSE
Air-Breath. Prop.	F. E. PICKERING	GEN. ELECTRIC
Artificial Intell.	R. P. CAREN	LOCKHEED
Computational Science	A. N. CHESTER	GM/HUGHES
Optical Info. Process	R. G. ANDERSON	GRUMMAN
Rocket Propulsion	H. W. CAMPEN	AEROJET
Software Development	J. R. BURNETT	TRW
Superconductivity	R. P. CAREN	LOCKHEED
Ultrarel. Elect. Sys.	L. GIULIANO	ITT

Figure 2

REVIEW OF DOD CRITICAL TECHNOLOGIES PLAN

Lead Organizations

	1989	1990	1991
Chair	NSIA	AIA	EIA
Vice Chair	AIA	EIA	NSIA

Figure 3

Senator BINGAMAN. Thank you very much.

I will begin with a few questions and then defer to Senator Smith for his questions.

Let me start with the larger picture that we have tried to address somewhat, and get first Dr. Herzfeld's reaction and then Admiral Barr's and Mr. Swihart's on any changes that you recommend in connection with this.

We recently issued the first report of a National Critical Technology Panel which is half industry, half government. The Department of Defense, the Department of Energy, and industry are represented on that group and have been very active.

The idea was that we would take the work of each of the agencies that has a concern about these critical areas of technology development, and we would take each of the industries that had shown the initiative to work in this area and try, to the extent possible, identify a consensus on areas that needed greater attention and greater cooperation. I think that to some extent that is beginning to work, and I think this first report we received from the Office of Science and Technology Policy (OSTP) through this National Critical Technology Panel has been useful.

The process that we have in the law today calls for a biannual report by a National Critical Technology Panel. A new panel is appointed every 2 years and issues a report, and that will continue through the year 2000.

We have an annual report which is being done by the Department of Defense, and which I think is properly described by Dr. Herzfeld here as more of a working document for purposes of budgeting and planning within the Department of Defense.

Is it appropriate to continue DOD's Critical Technologies Plan on an annual basis, or should we think in terms of a biannual plan that would be more in line with the national critical technology report that was issued?

Dr. HERZFELD. That is a very interesting question because it addresses something we have been kicking back and forth in our building already for some months now. In fact, it turns out that our internal planning process is a 2-year process. When you take the beginning of the inputs to the guidance until you get to the Presidential budget, it is about a 2-year cycle.

Senator **Bingaman**. Is it a 2-year cycle that begins each year?

Dr. **Herzfeld**. That is right, but it begins each year when we update for the off years because we have to think about reprogramming and, of course, have to come to the Congress for permission if we exceed the thresholds. Additionally, we have to think about allocating the funds, reallocating, and making some other adjustments for the off year.

But as we plan for fiscal year 1994 budget, which is the next major Presidential budget, my inclination would be to suggest not changing course now. Let us think in terms of coming out with a report next year, but let us be aware of the fact that the report may not be all that different in terms of what it says about 1993 or 1994, but that the really big changes will show up a year after that. We may wind up having alternately major changes and minor changes. The discipline of going through it every year still appeals to me, and if there are not a lot of changes, it will just be easier to do.

Senator **Bingaman**. Since it is a planning document that is useful in focusing on where you are going to put resources, I think an annual process might make some sense.

Dr. **Herzfeld**. Yes.

Senator **Bingaman**. I am interested in that reaction.

Admiral Barr, I have not had a chance to really review the annex that you supplied this year. I am glad it was supplied. However, it is issued in confidential form. Is it possible to get an unclassified version of that which could be made public so that it could be discussed more openly in hearings?

Admiral **Barr**. Senator, my evaluation was that while each of the individual technologies are not classified, if you look at the whole thing put together where we have defined what we believe to be those technologies critical for the nuclear weapons area, that was in composite something which we would not want to have made public. We can certainly look at making an unclassified version if that would be helpful.

Senator **Bingaman**. I think it might be helpful to at least consider that. It strikes me that we are neither fish nor fowl here. We have a document that is classified as confidential. We have so many levels of classification that are more serious than confidential, I would think we would either classify it at a higher level or do most of this document on an unclassified basis.

Admiral **Barr**. Yes, sir. Let me look at that, sir.

[The information follows:]

The Department of Energy Nuclear Weapons Critical Technologies Annex to the Defense Critical Technologies Plan was classified because it contained information concerning the nuclear weapons program, the release of which would be detrimental to the national security. The Department is reviewing this document to determine whether it can be modified in a manner to remove classified information and yet still remain a meaningful document. We will provide you with the results of this analysis as soon as it is available.

Dr. **Herzfeld**. Could I address that point, Mr. Chairman?

Senator **Bingaman**. Yes, sir.

Dr. **Herzfeld**. We also considered this issue quite a lot, and I must say I offer the unclassified version with some misgivings and concerns. I share Admiral Barr's concerns. I think there is a real policy issue here that needs to be thought about more, and perhaps we need to have some private dialogue with you and other members. I had to make the personal determination whether this document was classified or not, and I sought appropriate advice and thought about it a lot. It is where it is, but I do wish to express my concern about the matter.

Senator **Bingaman**. My time is expired. Senator Smith.

Senator **Smith**. Thank you, Mr. Chairman.

With these plans and reports that are required by Congress, some of the folks in defense industry and the Defense Department feel they bog them down. Has this helped you? Be honest.

Admiral **Barr**. Yes, sir. It has helped us a lot, and I can speak, of course, for the annex. As I mentioned during my testimony, this is the first time that the laboratories have collectively sat down together and tried to sketch out all the technologies that really contribute in an organized way and then pick out of those the ones that are critical that are changing rapidly enough that we really have to keep abreast of those. So, it was an extremely beneficial exercise for us, and I think it is going to pay big dividends for us and will be a very useful planning tool.

Mr. **Swihart**. Could I respond to that also, Senator?

Senator **Smith**. Certainly.

Mr. **Swihart**. I think that, as you noted in my testimony, 40 percent of the industry's IR&D is going into our 11 key technologies. I have super support from the industry on a voluntary basis. We estimate that each one of these national strategic plans that we have put together so far has had an equivalent cost of about $3 million. We have had more than 1,000 people involved to get a consensus on each one of these plans. The industry is using these to drive their own internal IR&D. So, I think that we have given a lot of support for this program.

Senator **Smith**. This type of technology is changing rapidly and surging forward. You have 21 items listed there as priorities. What process do you use internally to keep that updated, to remove, or place new items on? How does that process work internally?

Dr. **Herzfeld**. Let me comment on that please, but first also let me answer your last question. We too found it very useful. It focuses one's mind wonderfully if you have to produce a report that the Congress and the whole world will see. It really does.

Senator **Smith**. So, this is a report that really helps.

Dr. **Herzfeld**. Yes, this one did and will continue to.

The process basically starts with an examination of two things. What do we expect the future military needs to be, and what do we expect the future technological opportunities to be? And you have to get experts on both into the same room talking about the same thing and arguing quite a bit and trying things out and shooting down ideas that are not any good. It takes a while; it takes good people; and it takes a lot of time. As Admiral Barr and Mr. Swihart indicated lots of people have worked on these documents, and they are very good people. They are the best we could find.

For each technology, each of the 21, we have done that with groups that included people from the services, from the DOE labs, from Commerce, from all over, and then have checked some of these out with the industrial association people. We have looked at the military need, which has to drive our programs, at the technological opportunity and at the issue of how much money it takes to get there. Will the product be something that is affordable? Can it be made sufficiently easily? Is it maintainable? All these things have to be considered. Now, the degree of detail varies from case to case. You cannot make a blanket statement and say everything was done equally well or equally poorly.

But I think we have a good process going, and it is one that the services have accepted. The laboratories are signing up to these objectives. The users in the services are signing up to the potential applications. So we are beginning to tie the whole system together around this plan. I think that is one of the main contributions. I believe that was the intent originally.

Senator SMITH. I can't recall the number. I think it was 15 in your report that you listed as dual-use. Was it 15?

Dr. HERZFELD. Yes.

Senator SMITH. How do you deal with a dual-use technology which can affect national security both from the industry's point of view and from the defense point of view? How do you move that technology along when you have the private sector out there and you cannot tell the private sector what to do, what not to do, but on the other hand, you have to use that technology? Explain how you compensate for that and still move the technology forward?

Dr. HERZFELD. It is not that hard actually. I think in most instances it falls out pretty cleanly.

Let's take microelectronics for one, which is, of all the key technologies, one of the top, and most important ones. It is equally essential for the private sector and for the defense sector. We cannot have either without that technology. We must drive the technology forward as fast as we can reasonably do so, looking at new materials other than silicon, looking at ever finer, smaller feature size on chips, making chips more cheaply, and all that.

We focus on that because we need radiation hard electronics, which suggests some materials other than silicon. The private sector is not terribly interested in gallium arsenide by and large, though some supercomputers do use some gallium arsenide based parts. We are interested in half micron-size, feature-size electronics, and quadramicron, as small as we can get. So is the commercial sector, but we want to do it because we want to package more functionality into a small box. In the end everybody wins.

We are very happy about the dual-use in the sense that we find a way in many, many areas, in most of the critical technologies in fact, where there are direct spinoffs and direct benefits. We have no compunction about that at all. What we cannot do under our view of the budget and the policy, is do things only for the private sector. That is not the Defense Department's job. Those issues come up much more rarely than one would think.

Senator BINGAMAN. On funding issues, the appendix A attached is very detailed with regard to program elements and identifying the usually relatively small amounts that are devoted to particular critical technologies in each program element.

I guess the obvious question which comes up when you look at appendix A is should we have program elements for each critical technology? If in fact these critical technologies are going to be largely the ones we pursue over the next decade, doesn't it make sense instead of going through with our existing program elements and trying to identify a couple million here that is being spent on it and a couple million there, that we would have a program element for each of these?

Dr. **HERZFELD**. We thought quite a lot about that recently in response to your earlier questions, and I think we really understand what the answer is. For some types of money we can do it, and for others we can't. Let me try and explain.

Basic research is 6.1, and you can say we are going to work on microelectronics. We are going to work on computing, and that's it. There it may make sense; and in fact, some of the service programs do that, do have program elements that are designed by field, by subject matter.

At the other extreme of science and technology in 6.3, you build gadgets. You might build a sensor package that has in it a new sensor, a new computer, and new materials; and that comes in a program element that is called infrared targeting. I don't know how we can disentangle these.

Senator **BINGAMAN**. I understand your point. Does it make sense to have program elements within the 6.1 line for each critical technology?

Dr. **HERZFELD**. I think that would be relatively easy. For 6.2 it is a mixed case, and for 6.3 I see no plausible way of doing that without creating the same kind of confusion in the opposite direction. One runs programs as programs and not so much as what the technology content is. The program element is supposed to be useful to the program manager at some level in the Department or in an agency.

Senator **BINGAMAN**. But by definition, 6.1 funding should be focused on technology areas.

Dr. **HERZFELD**. There it would be relatively easy to do, I believe. I would not recommend it in the other two for the reasons I explained.

Senator **BINGAMAN**. Is multi-year funding authorization important for us to consider doing in the Congress in these areas? Is that something that is not a significant item as far as the actual impact it might have on what occurs?

Dr. **HERZFELD**. I think there are a good many pluses to it. One question would be how many years of funding one would think about, and I think that requires some more thought. If you like, we can take that into consideration and come back to you with a position. I have not thought it through adequately enough to give you a good answer now.

You have to balance two things. We want more stability, and we are trying to achieve that. This plan will help us very, very much toward getting the stability. On the other hand, you need to keep the flexibility because both technology and military needs have a habit of changing suddenly and dramatically, and you have to respond. So, we have to find the right way to do that, but I think good arguments can be made.

Senator **Bingaman**. Admiral Barr, we introduced last Thursday a couple of bills I want to call to your attention, Senate bill 979, which is a Department of Energy Critical Technology Act. This bill directs the Department of Energy, both the defense side and the non-defense side, to go through a similar process which would not be limited to the nuclear weapons field, but would be more broad based. I would be interested in your reviewing that, and giving us your reaction as to whether that is useful or counterproductive.

In addition, Senate bill 980 which deals very effectively with what you have identified in your annex as engineered materials—advanced materials synthesis processing and commercialization. This bill addresses that from a government-wide perspective, but gives priority to that because our strong sense is that this is an area that has needed a much better focus and coordination than we have had in the past.

Admiral **Barr**. Yes, sir.

Senator **Bingaman**. I do not know if you are prepared to comment today on these bills, but I would appreciate knowing your views in the near future.

Admiral **Barr**. Yes, sir. I have had a very quick look. And certainly I think the concepts are very good, but I would appreciate the opportunity to look at them in more detail and get back to you.

Senator **Bingaman**. We would appreciate that. Obviously, Dr. Herzfeld if you have thoughts on the DOE bill and the government-wide bill in which the Department of Defense and the Department of Energy both play a significant part. Mr. Swihart, if you have thoughts on it, I would be anxious to hear those too.

Mr. **Swihart**. Thank you very much.

[The information follows:]

DOE's Position

1. While the objectives of S. 979 are laudable and can be supported by the Department of Energy, we do not feel that the bill in its present form would be effective in achieving its objectives and should not be supported.

2. Our detailed comments are summarized below:

Section 101 requires the establishment of a Critical Technologies Council.

- This is unnecessary and represents an intervention into the management authority of the Secretary.
- DOE is already accomplishing the consideration of critical technologies as they relate to DOE missions and the core competencies of DOE facilities through:
  - The Institutional Planning Process for the labs
  - DOE's integrated Strategic Planning and Budgeting Process
  - DOE's active participation in the interagency community and its committees/working groups
- How critical technologies are to be determined is unclear; several critical technologies documents are referred to in the bill.
- The representation required for the Council poses legal, administrative, and institutional difficulties related to having contractors in policy-making and management oversight roles.

Section 102 provides for a Critical Technologies Advisory Board to be formed from the Secretary of Energy Advisory Board (SEAB).

- This conflicts with the current mission and outlook of the SEAB (which is long range/long term) and would inappropriately involve this advisory body in a short-term oversight role.
- This creates an additional demand on this group's time to the detriment of the requirements established by the Secretary.

Section 103 requires the development of a Critical Technologies Plan every 2 years.

- This requirement is unnecessary and duplicative of other ongoing DOE and administration processes.
- This requirement is inefficient in that DOE does planning based upon its mission and develops cross-cuts as derivatives of this planning. Critical Technologies are not a DOE mission; capabilities in critical technologies are a product of DOE's mission accomplishments. DOE has developed an integrated planning process which does address cross-cutting issues such as technology transfer, and could be used to evaluate DOE's contributions in so-called critical technologies.
- The proposed DOE Critical Technologies Plan would be counterproductive given the responsibilities of our sister departments and agencies in some critical technologies areas and the effective management of DOE and other national laboratories in programmatic mission areas.
    - DOE already participates in the National Critical Technologies Panel process.
    - DOE already participates in Department of Defense critical technologies activities such as the Militarily Critical Technologies List
    - DOE already works with the Department of Commerce in the area of emerging technologies
    - DOE already participates in critical materials panels, manufacturing technologies forums and a host of already existing official and quasi-official forums that contribute to addressing this area.
    - DOE already coordinates research and development, for example, in the High Performance Computing area, with other agencies through the FCCSET process. Within DOE, High Performance Computing is integrated into existing program areas.

Section 104 directs DOE to prescribe regulations authorizing the use of Laboratory Directed Research and Development (LDRD) funds for technology transfer and for maintaining core competencies.

- The requirements regarding core competencies duplicate the Department's existing LDRD policy
- The requirement to use LDRD funds for technology transfer is inconsistent with current DOE policy. DOE's Technology Transfer Program addresses technology transfer and provides the laboratories with needed flexibility in this area. Technology Transfer has become a mission of the Department and research and development for the purposes of technology transfer is being funded as a direct program activity.

Section 201 requires the establishment of Critical Technology Partnerships.

- This is duplicative of activities already being carried out under the authority of the National Competitiveness Technology Transfer Act of 1989, the Federal Technology Transfer Act of 1986, the Stevenson-Wydler Technology Utilization Act of 1980 and other legislation.
- DOE is already addressing opportunities to increase the focus on such cost-shared partnerships with industry and academia through its Enhanced Technology Transfer Program.

Section 202 requires that cost-sharing be at least 50 percent from the non-Federal partner in all cases.

- While we endorse the objective we believe more flexibility is needed.
- In some cases, funding of generic, pre-competitive technologies are too far from commercialization to attract that degree of non-Federal support.
- In some cases, DOE's program requirements may justify a less than 50 percent non-Federal cost sharing.
- It is not clear that the other assistance that the Secretary can provide is limited by the 50 percent cost share provision or how it is balanced.

Section 203 addresses the selection of partnerships.

- The section is vague as to whether these partnerships can provide funds out to industry.
- This section appears to overlay a specific, new process of solicitation and selection that appears duplicative and may be inconsistent with existing procurement, grant, joint venture, and Cooperative Research and Development Agreement (CRADA) processes.
- The section does not address the full range of competitive issues, such as whether some partnerships can be set aside for small businesses, etc.
- The potential for the Secretary to provide other assistance could provide a source of potential litigation. For example, an unsuccessful competitor could later

charge that an awardee that received other assistance was erroneously selected and that all proposals should have been evaluated with the other assistance factored in.

Section 204 addresses protection of information.

- The current language poses some difficulties in interpretation in that the terms "Federal laboratories," "research and development," and "Partnership" are not defined.
- The provisions represent a fairly significant extension of CIA type material which can be exempted from disclosure under the Freedom of Information Act and other legislation. We believe that a careful review to determine its full impact and potential requirement for conforming amendments to other legislation is needed.

Section 301 addresses authorization and appropriations.

- It is not clear that the funds identified will not be reprogrammed from currently projected program funds.
- DOE is currently integrating technology transfer into how do research and development and not merely a step to be performed after research is completed. This integrated approach in effect leverages substantially more funds than are being proposed in the bill.

Section 302 provides authority to waive applicability to classified programs.

- We have no objection to this standard provision.

In conclusion, DOE could support necessary legislative actions to better utilize the resources of DOE's laboratories but we do not believe that S. 979 as drafted will accomplish this goal. Our resources would be better utilized in making full use of the authorities already provided under the NCTTA through DOE's Enhanced Technology Transfer Program. Therefore we cannot and do not support S. 979 as it currently stands.

Senator BINGAMAN. I thought the addition of flexible manufacturing to the plan this year was interesting. One of the themes that you identify early in your plan is "radical acceleration of the development, introduction, and use of flexible manufacturing technology and training technology".

I agree totally with the emphasis on flexible manufacturing. I have trouble seeing anywhere in the budget that we have been given by the Congress, or even in your plan where you lay out the plan funding levels for the next 5 or 6 years, the kind of emphasis that would be reflected if you were seriously pursuing some kind of so-called radical acceleration. I think you have $27 million this year. You are going up to $31 million by 1997. That is not very radical around here.

The one cluster that gets the most overlap with your critical technologies is materials and manufacturing, and yet when you review the funding for the 21 critical technologies, by far the lowest funding level is committed to flexible manufacturing.

Dr. HERZFELD. In part, Senator, it is due to the way we define flexible manufacturing because we tried to get a relatively narrow technical focus. But, as you point out, many of the other technologies contribute to the materials and manufacturing cluster. Computing is a very important part of it and supports the flexible manufacturing budget line. Without the high performance computing initiative, we would not be in a position to get a complete computerized management of the factory process as quickly as we will be with it. And that is a very important application. In fact, it is an application of the government-wide high performance computing initiative because the Commerce Department has an interest in this also, and so does the DOE, by the way, in its computing initiative. There is more than meets the eye here. That is point one.

Point two is that this is really our first look at what needs to be done, and I cannot tell you today what the numbers will look like next year because I do not know. All I can say is this was a first look, and this is what we have come up with, and it is the best we could do at identifying what we see we can do.

One of the problems, as you know, is that lots of other people are working on it, and we have to fit our program in some smooth way into what everybody else is doing. Industry is doing a lot about it. Commerce has a large program on it. And we simply do not know enough to have a definitive answer to your question, but next year we will have that laid out much better, I believe.

Senator **BINGAMAN**. Senator Smith.

Senator **SMITH**. Dr. Herzfeld, your statement itemizes funding levels in all the critical technologies. The SDI research and development portion represents a substantial share. If you look at the President's budget, it's 9.8 billion with it, 5.3 billion without it. The numbers are illustrated across the board.

Is the ABM Treaty hindering what you are doing in critical technologies R&D?

Dr. **HERZFELD**. If I may be factual, the answer is that the SDIO budget that gets appropriated is what is hindering what we are doing. The SDIO budget in 1991 was appropriated at $2.8 billion, and the critical technologies part of that went down to $650 million from almost a billion the year before.

Senator **SMITH**. We need to ask ourselves why this is happening in Congress. Would you like to see R&D funding increased? Should SDI be fully funded?

Dr. **HERZFELD**. Yes, absolutely.

I don't think the treaty is really the issue here. The fundamental defense issue—and this is off critical technologies, but very, very important—is that the President, the Secretary, and all the rest on this team believe that defensive systems, ballistic missile defense for theater and for the United States, is an important part of our military posture. And we all know there is a lot of debate and disagreement on that within the Congress, and the programs that the President asks for are the programs that we would like to have.

Senator **SMITH**. Admiral, let me ask you a specific question. DOE includes both laser and directed energy technology on their critical technologies list. Yet, Congress continually cuts these programs in their defense budget. How do you deal with that? If it is critical and we are cutting it, aren't we damaging our national security?

Admiral **BARR**. Well, first of all, sir, in the laser area with the Inertial Confinement Fusion (ICF) being a major part of that and a lot of other areas, we have not been cut nearly to the extent in that we have been in the nuclear direct energy area. We have been substantially cut in that, and we are back now to about an $80 million a year program when a few years ago, it was up to about $300 million a year. When I came here 2 years ago, it was twice what it is now. So, the ability to go forward and investigate a number of different nuclear directed energy weapons (NDEW) concepts is clearly reduced.

We think we are now at a level where we cannot afford to go any lower or else we are substantially going to cut into our ability to assess threats. That is really what we are talking about in the Department of Energy's NDEW program, the ability to assess the potential, what can be done, so we are aware of what the threats might be. So, there is a linkage, but since this is the first year we have done the Critical Technologies Annex, I think we could say we are at a level now which, while I would hesitate to say we are comfortable, it is not one where we have been cut so badly from the critical technologies aspect that I would have to cry foul.

Senator SMITH. Well, I am not trying to put words in your mouths, but as I see it, looking just at the President's request, you are roughly $4.5 billion shy of money that you believe is critical to our national security. Is that a fair statement?

Dr. HERZFELD. I'm sure what——

Senator SMITH. If we take out SDI.

Dr. HERZFELD. Oh, yes, of course. That's right, and it would impact the critical technologies that apply more or less across the board quite significantly as well.

Senator SMITH. As you are probably aware, it is Senator Warner's thesis—a member of this committee—and some of us strongly agree with him—that the budget figures are being driven by the restrictions of the ABM Treaty. Now, I realize you are not in the policy end here, and I am not trying to put you there. But I am concerned about the issue. You are the folks who are managing this technology, and you are the best qualified to say whether or not there is something hanging over your head that prevents you from moving where you feel we need to move.

Dr. HERZFELD. Let me address that because I am responsible for the people who certify compliance with the treaty of SDI tests, and I [illegible] a lot of time looking over their shoulders and understanding [illegible] they are certifying.

As Ambassador Cooper has testified, the treaty is beginning to impact the program because we need to do things in a more complicated way than we would otherwise if the treaty were to operate differently or be modified in certain ways. These more complicated ways take more time and cost more money. He has testified to that before this committee and others in some detail.

I think that is the case. That is exactly right. We have not yet run up against a hard stop, but we can foresee problems arising. In particular, there are some long lead items for future experiments that need to be purchased soon, and we have not gotten appropriations to do that; so we are beginning to feel the impact. It is not very dramatic yet, but it does impact the program. I believe this is a matter that requires very careful examination and dialogue on a pretty wide front.

Senator SMITH. Thank you very much.

Thank you, Mr. Chairman.

Senator BINGAMAN. Let me follow up on that because my perception is that the cuts in funding for critical technologies that have occurred in the SDI budget have not been ones mandated by Congress. They have rather been a result of the internal priorities of the SDI Office, and the SDI Office does not put these so-called critical technologies as their highest priority concerns in many cases. Therefore, when Congress each year cuts the SDI budget and the SDI Office is given less money to work with, one of the first places they look to make those reductions is in the so-called critical technologies accounts. Is that an incorrect perception?

Dr. **Herzfeld**. Let me comment on that. It is roughly right, Mr. Chairman, but one has to realize that SDIO is under a Presidential direction to do a particular job.

Senator **Bingaman**. By a particular time.

Dr. **Herzfeld**. By a particular time. And the job is pretty hard, and the time is not very long. And the funds are not really terribly adequate, at least in my judgment, and I think Ambassador Cooper would agree with me. So, when they are driven to the wall, they know what has to go: and it is a pretty agonizing process. There is nothing automatic about it. The Ambassador and I confer regularly on this. Really, we are trying to be as helpful as we can, and there is a lot of cooperation here. But the big realities that you laid before us are there, and they drive the situation.

Senator **Bingaman**. As I have stated in past years, I believe it is a mistake to have critical technology funding in SDI's budget. It is the piece of the Department of Defense budget which is most controversial when it comes to the Congress because of the desire that Ambassador Cooper and the administration have to go forward with a system which would, once tested and deployed, violate the ABM Treaty, and many people in Congress, of course, object to that. That mission is very controversial, and to put SDI funding together with so-called critical technology funding in an area that is almost certainly slated for a significant cut by Congress winds up cutting the funding in the critical technologies area. The critical technology funding has to, as you say, at least in the view of the SDI Office management, take a second seat to the primary mission.

Dr. **Herzfeld**. The difficulty that I see with proceeding the way that I think you are suggesting is that if you fund the critical technologies in SDI separately, you then make it more difficult to manage an integrated program. One of the efficiencies that the country gets by our current procedure is that SDIO really runs an integrated program. They draw on all defense technology. They also draw on DOE technology and on civilian technology, but they have their own technology program to support their programmatic objectives. And as everybody who is a big program manager knows, that is the way to do it. That is how the Navy Special Projects Office got the nuclear submarine Polaris story together, by having all the assets that are required reporting to one person who was totally accountable and totally in charge. That is how you get that kind of a complicated job done, I believe. There are pros and cons, obviously, but I think they need to be debated pretty carefully.

Senator **Smith**. Would the Senator yield for a comment on that?

Senator **Bingaman**. Certainly. Go ahead.

Senator **Smith**. I think that is a very perceptive statement, Doctor, because it is my impression that instead of having 21 individual line items up here of these technologies, we in fact have an integrated plan. It is my belief that we should not isolate SDI any more than any other technology, although it is obviously more important than some. I think you are correct, and I agree with that statement.

Thank you, Senator.

Senator **Bingaman**. Let me ask about display technologies such as liquid crystal display, and flat panel displays. On page 68 of the report of the national panel, it states, "The Europeans undertook a major program to develop high definition imaging and display technology in 1986 and are not far behind the Japanese. U.S. efforts in this area have been extremely limited and capabilities are far behind those of the Japanese and the Europeans. Moreover, the prospects for a significant increase in U.S. efforts are poor because the market prospects are too long-term and high risk to justify a substantial increase in privately funded R&D and national security requirements alone do not support a major commitment of defense funding."

I asked Admiral Inman about that statement, and I believe it is fair to paraphrase him as saying that he disagreed with the last part of that. He felt that national security requirements did justify a major commitment of defense spending to deal with the problem of display technology.

I would be interested in knowing why Admiral Inman's view is not reflected anywhere in this report. As far as I can tell, the Department of Defense is essentially saying we can do without any capability in this area and buy whatever is available.

Dr. **HERZFELD**. I think that is really a statement that describes the past. The current view is different. As you know, the Congress appropriated some substantial funds for DARPA of over $70 million in fiscal year 1991 for high definition displays, and as you also know, DARPA was allowed to keep the money and build a program with it, which they are doing.

Senator **BINGAMAN**. As I recall, nothing was asked for in 1992.

Dr. **HERZFELD**. Because we are out of cycle, Mr. Chairman. The 1992 budget was based on guidance which was constructed in 1989.

Senator **BINGAMAN**. The budget we received earlier this year does not reflect current thinking?

Dr. **HERZFELD**. It does not reflect all of the current thinking because we could not get it in.

Senator **BINGAMAN**. I see.

Dr. **HERZFELD**. The Presidential budget that was submitted was put together last summer, the summer of 1990. There were many issues, of course, as there always are. Some adjustments were possible and some were not. What I would like to suggest is that you let us work the problem and the next round we will come with an updated view, which may be different.

The DARPA program is very energetic. They are getting extremely good results. Dr. Reis has testified to this before some other committees already, and you may wish to hear about it. In fact, the money that was appropriated is probably good for more than 1 year's worth of programs. It is quite a lot of money as such things go. It will stretch into the next fiscal year as well, but we will be back with a new look next cycle.

Senator **BINGAMAN**. My quick review of your 21 technologies this year did not reveal anything to do with display technology. Did I miss it? Is it in there?

Dr. **HERZFELD**. It is in there, but not very visible and that will get fixed also, Mr. Chairman. Let me throw myself on the mercy of the court on this one—[laughter]—and say we will do a better job and make that very visible next year.

Senator **BINGAMAN**. Okay.

When we had our hearing, again Admiral Inman was commenting, and the report of the Council on Competitiveness made the point very strongly, that we do better in technologies where we find that the so-called technology is really closer to basic science. We are much better there than we are in having the capability to actually produce the weaponry or the technology.

When you refer to the funding tables in the report, it seems to me that again we are emphasizing basic technology, and I understand that. But DOD seems to be saying that the fostering of dual-use technologies and the capability to produce dual-use technologies is really not DOD's problem.

I am interested in knowing if we are going to wind up in a situation 6, 8, 10 years from now where we have great capabilities in our national laboratories to claim some kind of world leadership in these critical technologies but have lost any ability to apply them to actual use in defense systems. If so, are we giving enough attention to that problem?

Dr. **Herzfeld**. That is, of course, the critical challenge here, and let me comment on this. There are a couple of comments to make.

First of all, the overall reform of the acquisition process, which has been going on now for 2 years and which continues, takes into account the problem you describe. As part of that process, the program managers in each major program have to show in some detail how they plan to support the establishment of the appropriate production capability with the contractor who implements the program. That is point one, and it is very important.

The second point I would like to make is that the programmatic and policy direction of manufacturing technology per se is not something that I am responsible for, Colin McMillan, who is the Assistant Secretary for Production and Logistics, is. We work together at the working level and personally quite well on this, but it is really his part of the action that you are addressing.

The final comment I would like to make is that DARPA, under the leadership of Dr. Reis, has begun, as part of the reorganization that everyone has been hearing about, to ensure that every one of the major program thrusts in DARPA pays attention to the technologies and the engineering or manufacturing of any products that come out of it. It is true for computers. It is true for sensors. It is true across the board. It is a new look at DARPA, where part of the development contract in more and more cases is a task to get the manufacturing base established, should manufacturing take place after the development. I think it is very important. It is a revolutionary step. And this, together with some of the other things we have described, if it really holds on, will provide this dramatic improvement in perhaps 5 years.

Senator **Bingaman**. Admiral Barr.

Admiral **Barr**. Senator, could I add something to that?

Senator **Bingaman**. Certainly.

Admiral **Barr**. In our weapons laboratories, I think one of the real strengths is that they are involved from basically the most basic research through actual production of nuclear weapons. You have a sort of a coherence there which does involve designing for manufacturability, transferring processes from our laboratories to our production plants. So, there is an integrated continuum there, and I think a very important factor here is our tech transfer initiatives which I think my quick look at the bills that you mentioned earlier will help us in that area that we need to ensure are the tech transfer is really pushed so that where we are able to, we can get together with industry and transfer. I think the laboratories do have a strength in that area that can be used.

Senator Bingaman. Mr. Swihart.

Mr. Swihart. Senator Bingaman, can I comment on that also?

Senator Bingaman. Please.

Mr. Swihart. Every one of our 11 key technologies has both a technologist and a manufacturing person teamed to run it because we have to change our culture. We have to get from idea to world class product faster. So, we are cooperating right from the very beginning to figure out, as the technology matures, how to get to that product, and we are working on that. That is one of our key drivers. We just have to cut the time from basic idea to world class product in half relative to what we are doing today. That will also help us double our productivity, which is our other goal.

Senator Bingaman. Thank you very much.

Senator Smith.

Senator Smith. Mr. Swihart, let me just pick up on that. The critical technologies plan outlines our technological priorities. Tell me from your own perspective how this influences the decision making process in industry.

Mr. Swihart. I think fundamentally, Senator Smith, that whenever the industry looks and sees that the Department of Defense, Department of Commerce, OSTP, NASA all have common elements, they have common critical key technologies, industry in turn can look at this.

And AIA did this before the fact, by the way. We came up with a list before anyone else came up with a list. We looked at those things and said, hey, that is the future. That is where we have to go. We have to put our own internal research and development down this alley because our job is to make world class products whether they are for military or for commercial use.

Senator Smith. There is a certain amount of insecurity there, too, isn't there? You have had the rug pulled out from under you before in this process. On again, off again on this or that program. One President says build it. The next President says don't build it. Another one comes by and says build it. This is difficult for industry to respond to and to keep assembly lines going.

Mr. Swihart. We look at this program, at this level as generic and precompetitive. So, we are cooperating together to pool our resources, to improve our productivity because the 11 technologies that we have are very similar. They are two-thirds of Dr. Herzfeld's list actually. We look at those technologies as something that absolutely must be mature in order for us to build the world-class products, to leap frog our international competition whether it is in military or commercial or space.

And we are not concerned, I guess at this level, about getting the rug pulled out from under anybody because as soon as one person thinks that he sees a way of making a better mousetrap, he can go off on his own and do that. There is no restriction on companies running off doing their own thing, but while we are working at this precompetitive, generic level, we can all work together very effectively.

Senator SMITH. Admiral, I was concerned about a comment that you made earlier. I don't know if you used the term "brain drain", but basically that is what you were referring to. In your opinion, is that happening strictly because of budget cuts and because you cannot compete at the government level with the private sector or is there some other reason?

Admiral BARR. It is budgetary primarily. Since the laboratories are not government employees, they are not restricted by the financial remuneration that some of the laboratories are. So, the pay is not an issue. I think you just have to look at what has been happening to the entire budget. We are being forced to run a balanced program with significant budget constraints, and this is one of the outcomes.

Senator SMITH. I have just one final question. Let me ask you, Mr. Swihart.

A very specific program that we have all been looking at here in the Congress is tiltrotor technology on the V-22, Osprey. In listening to testimony from the Joint Chiefs and other officers, there seems to be mixed feelings on the importance of this technology. The Army seems to feel that their helicopters are adequate, but the Marines do not. Where do you view this technology? Is the tiltrotor going to be part of the national scene in the future?

Mr. SWIHART. Well, I am somewhat biased you have to understand. I personally believe that tiltrotor technology has very positive application in the military. I think the idea of being able to fly at more than 300 knots, which you are not going to do with a helicopter, and fly like an airplane, take off and land vertically—in the whole flight regime, that is a minute or two each flight, the rest of the time you are flying like an airplane with the efficiency of the airplane—has a great deal of application.

On the other hand, I have to put my civilian hat on and say for a moment that if we get a completely independent air traffic control system so that you can bring those airplanes in without interfering with the normal traffic at a commercial airport, then it has civilian application. But without a separate air traffic control system, it is doubtful that that airplane has significant civilian application.

Senator SMITH. One final point. From a civilian point of view, the technology, to say the least, has great commercial implications if it is developed. I am not a scientist, but if we ever develop that technology in commercial aircraft, it has obvious advantages to compensate for runway shortages and other problems that we have with our airports around the country. I can think of a couple, one in my own State, where people have houses along the airport which end up being condemned, or they are forced to listen to the excessive noise. It seems to me that this technology is well worth pursuing. I am interested in your comments on this issue.

Thank you, Mr. Chairman.

Senator BINGAMAN. Thank you.

I understand the Department of Defense and the Department of Energy have been discussing possibly entering into a memorandum of understanding on critical technologies to do more work and to somewhat formalize the interaction there, similar to what you already have in conventional munitions.

Admiral Barr and Dr. Herzfeld, do you believe that is a useful way to proceed?

Admiral **Barr**. Yes, sir, I think it is extremely useful, and the Defense Programs Office, together with Dr. Herzfeld's office, are actively working on it. That is in the early stages. I see that as a win-win situation. I think we are looking here primarily at those areas which are not specific to nuclear weapons so that there is a crossover between what the DOE and the DOD would do, but by putting those agreements together and basically leveraging the available funds, I think it is a tremendous idea with great merit. And, we are going to actively pursue it.

Dr. **Herzfeld**. I agree with that completely. Just right.

Senator **Bingaman**. Good.

Another area I wanted to ask about before we end the hearing is the issue of international cooperation. I was in Japan last week meeting with a group of Diet members. They were making the point that a high priority for our government seems to be getting their involvement, particularly their financial involvement, in support of the super collider project. I believe the entire cost of that project is going to be $8.2 billion, and we are soliciting $1.7 billion from foreign sources. They are the prime candidate to pony up some of that money, or at least we would like them to be.

Are we making any significant effort—I can't detect any—to identify ways to cooperate with the Japanese in those areas where we have clearly recognized a leadership position by them?

We have five areas out of the 21 where they clearly are ahead, and I would argue that in flexible manufacturing, we have them mischaracterized. I think the reports you have provided us today show that they are significantly lagging the United States in flexible manufacturing. That is contrary to what Admiral Inman indicated in his report. Regardless of how many of these areas they do have a lead in, are we doing anything significant to involve ourselves in cooperative efforts with them to try to learn what we can about breakthroughs and capabilities that they are developing?

Dr. **Herzfeld**. Yes, Senator Bingaman. Again, this is someone else's prime responsibility. Al Kelly is the Deputy Under Secretary for International Programs in OSD, and he is handling this now. He is, indeed, negotiating on the five areas of joint work that are being considered where the Japanese have very specific technologies that we would like to work on with them. These are militarily oriented technologies.

The issue of the flexible manufacturing is under consideration right now. There are some pros and cons that need to be looked at about how we want to do that. We want to make sure that both sides bring enough to the party to make it worthwhile for both sides. And it happens not to be easy in this area.

I agree with you that we mischaracterized their performance, and no doubt there are other details that have to be corrected in the report. We will look at that. But we are examining how to work with them, but no decision has been made in this particular area. The five areas where Dr. Kelly has been working with them are going forward.

Senator **Bingaman**. Admiral Barr, let me just be a little more specific in the question to you. For example, the Department of Energy to my knowledge has one scientist who is now working in a cooperative research project in Japan. I think that is Jeff Willis who is still at the superconducting center, ISTECH, which is outside of Tokyo.

It would seem to me, as I told your Department of Energy representative in the Embassy there in Tokyo when I was there, that there would be many opportunities or many benefits for DOE laboratory personnel to try to involve themselves in some of those joint projects that are ongoing there in some of these areas where the Japanese clearly have a lead.

Is there anything going on in your Department to try to pursue this more aggressively?

Admiral **Barr**. Mr. Chairman, not that I know of, but let me take that for the record because there will be some activity which I am just not aware of, and I will get back to you, sir.

[The information follows:]

The Department of Energy is cooperating with Japan in the development of low temperature superconducting magnet technology in support of both our fusion and high energy physics programs. The cooperation in fusion energy has been ongoing since 1977, and at present the major activity involves the testing of magnets to support the International Thermonuclear Experimental Reactor. Test results will be shared equally, but each party will retain the specific technical know-how to manufacture superconducting cable and magnets. Under the U.S.-Japan agreement on High Energy Physics, the Superconducting Super Collider Laboratory has been working with the Japanese national high energy physics laboratory (KEK) on superconducting accelerator magnets.

In the area of high temperature superconductivity research, the Los Alamos National Laboratory has assigned a researcher to work at ISTEC, a Japanese national laboratory for research into high temperature superconductivity.

Senator **Bingaman**. We will continue to urge more activity within DOE because I do think this is an area where we have been very slow to pursue cooperative activity.

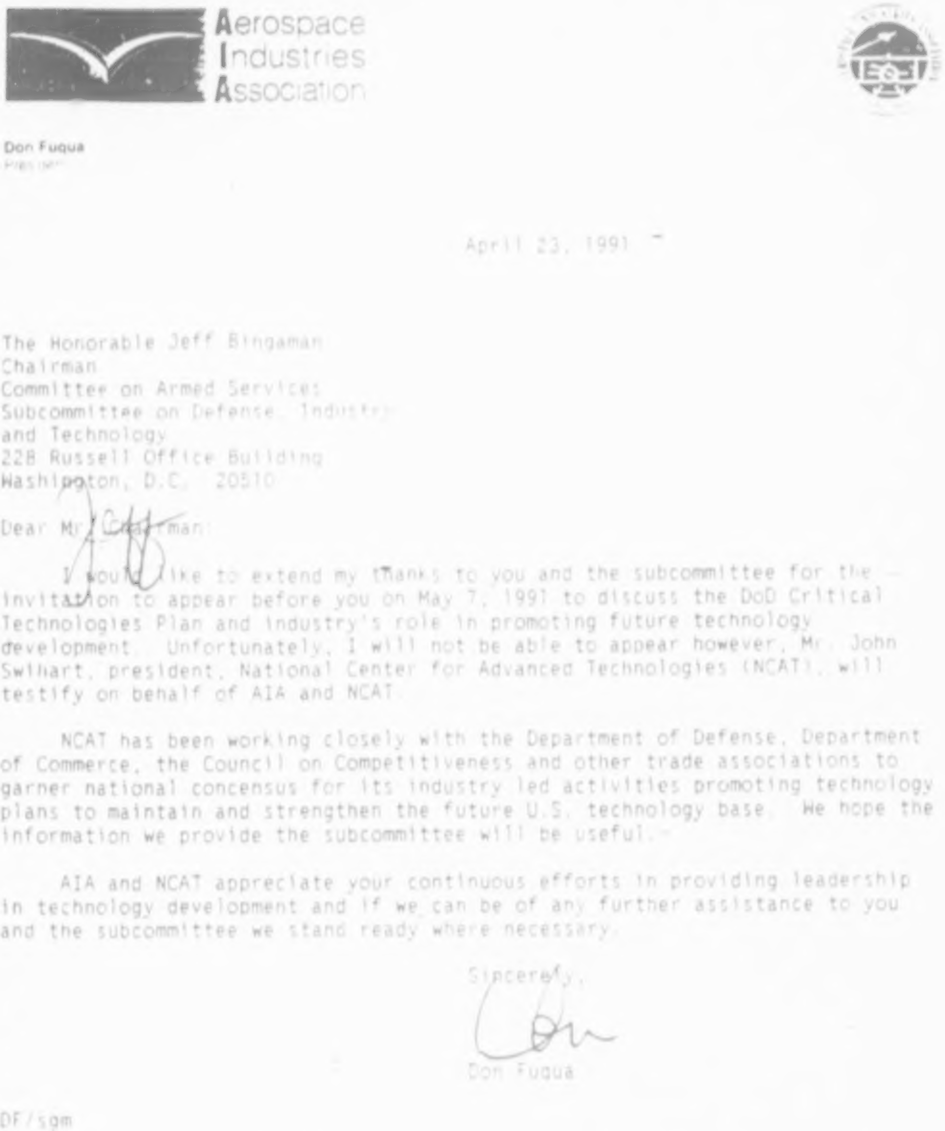
One other that I think you alluded to, Dr. Herzfeld, is more specifically in the Intelligent Manufacturing Systems (IMS) proposal, that the Japanese have made to our government and to the Europeans to pursue a 10-year project on flexible manufacturing and other advanced manufacturing types of activities. I know our response to that is being spearheaded out of the Department of Commerce, but it is my belief that the Department of Defense, because the Department of Defense has a very large budget related to manufacturing (relative to the Department of Commerce, it has a very large budget) should take an active part in formulating our policy and identifying benefits that we might achieve from that. I do not know if it is something that you have given attention to, but I would ask for any comments you have about the IMS proposal and urge that you give it attention if you have not had a chance to.

Dr. **Herzfeld**. That is very good advice, and we are looking at it, Mr. Chairman. I think it will become important as time goes on.

Senator **Bingaman**. I would say the same with the Department of Energy. I know that there are some significant capabilities in the Department of Energy in manufacturing, advanced manufacturing techniques, and perhaps there is some benefit that could be achieved there. I know that many of the members of your association, Mr. Swihart, are actively involved in trying to identify benefits from the IMS proposal.

I think the hearing has been informative and I appreciate your testimony today. We will continue to work with you on all of these things to see if we can get our act together a little better. Thank you very much.

[Additional prepared letter for the hearing record follows:]



Aerospace
Industries
Association

Don Fuqua
President

April 23, 1991

The Honorable Jeff Bingaman
Chairman
Committee on Armed Services
Subcommittee on Defense, Industry
and Technology
228 Russell Office Building
Washington, D.C. 20510

Jeff

Dear Mr. Chairman:

I would like to extend my thanks to you and the subcommittee for the invitation to appear before you on May 7, 1991 to discuss the DoD Critical Technologies Plan and industry's role in promoting future technology development. Unfortunately, I will not be able to appear however, Mr. John Swihart, president, National Center for Advanced Technologies (NCAT), will testify on behalf of AIA and NCAT.

NCAT has been working closely with the Department of Defense, Department of Commerce, the Council on Competitiveness and other trade associations to garner national concensus for its industry led activities promoting technology plans to maintain and strengthen the future U.S. technology base. We hope the information we provide the subcommittee will be useful.

AIA and NCAT appreciate your continuous efforts in providing leadership in technology development and if we can be of any further assistance to you and the subcommittee we stand ready where necessary.

Sincerely,

Don

Don Fuqua

DF/sgm

[Whereupon, at 11:32 a.m., the subcommittee was adjourned.]

DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993

WEDNESDAY, MAY 15, 1991

U.S. SENATE,
SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

SCIENCE, MATHEMATICS AND TECHNICAL EDUCATION

The subcommittee met, pursuant to notice, at 10:03 a.m., in room SR-222, Russell Senate Office Building, Senator Jeff Bingaman (chairman of the subcommittee) presiding.

Committee members present: Senators Bingaman, Nunn, and Coats.

Professional staff members present: David S. Lyles and William H. Smith.

Minority staff members present: Romie L. Brownlee, deputy staff director for the minority; Jonathan L. Etherton, professional staff member.

Staff assistants present: Camden Jones.

Committee members' assistants present: Eric H. Thoemmes, assistant to Senator Coats.

OPENING STATEMENT OF SENATOR JEFF BINGAMAN, CHAIRMAN

Senator BINGAMAN. The hearing will come to order. The subcommittee meets today to receive testimony on science and engineering education in the country and the role that the Department of Defense is playing in that area. The recent report of the FCCSET Committee on education and human resources notes that America is facing a "quiet crisis" in science and math education.

As evidence, it cites a decline in American student performance relative to our international peers. It speaks of the lack of preparation and the inadequate current scientific knowledge, among many American teachers. It notes the inadequate number of students pursuing education and training to fill critical scientific jobs and the underrepresentation of women, minorities, and persons with disabilities in science courses and careers.

President Bush and the Nation's Governors jointly established goals about 18 months ago. One of the goals was that U.S. students were to be number one in performance in math and science by the year 2000, first in the world. I believe all of us agree that that is a fairly ambitious goal considering that most international comparisons put us at 12th or 15th today, at least the ones I have seen. There is no argument between the executive and the congressional branches, or between the public and the private sectors that the Federal Government has a large role to play in reaching this goal. Secretary Cheney has encouraged the Defense Department to support the President's efforts to improve the technical education of America's youth. Secretary Watkins in the Department of Energy has demonstrated his support of this important initiative not only in initiating many new worthwhile activities within the Department of Energy, but also in serving as the chairman of the FCCSET Committee that prepared the inter-agency report on education and human resources.

On May 4 of last year, this subcommittee held its first hearing on Defense Department science and engineering education programs. Testifying for the Department at this hearing was Dr. Ted Berlincourt who stated that the Defense Department has a vital interest in the education of scientists and engineers. We agree with his assessment.

Dr. Berlincourt also testified, however, that the Defense Department did not have either the mandate or the authority to develop and conduct science and engineering programs akin to that held by the National Science Foundation or the Department of Education. He testified that any educational programs DOD conducted must be in direct support of the defense mission.

Based on that testimony, and on the discussion that followed, the Armed Services Committee included language in the defense bill last year to specifically authorize the Secretary of Defense to sponsor and assist in education at all levels, from kindergarten through postgraduate work.

The committee also learned, at its hearing on DOD in-house laboratories, of the success that the Army was having at its Electronics Technology and Device Laboratory in establishing partnerships to cooperate with local institutes of higher education in supporting science and engineering education. The committee used that as a model for a provision included in last year's defense bill that directed all DOD laboratories to enter into similar educational cooperative partnerships where mutually beneficial.

Finally, recognizing the importance that cooperative work education programs now play in engineering education, the committee included language in last year's bill that authorized laboratory directors to establish co-op programs on a competitive basis with private industry, and to not have the co-op students count against any total employment ceiling limitations that would otherwise apply.

Today we have Dr. Steven Kimmel, Deputy Director of Defense Research and Engineering, here to testify on the progress the Department has made in enhancing its support of science and engineering education using the authority that was provided in last year's defense bill. This is Dr. Kimmel's first appearance before the subcommittee as a witness, and we welcome him and we look forward to his testimony.

As a second panel, the subcommittee has invited three distinguished members of the engineering education community to share their views on the current state and future direction, of science and engineering education in America, and any thoughts they have about the role the Department of Defense can play.

Dr. Michael Thomas is the Executive Vice President at Georgia Tech. Georgia Tech, of course, is one of America's top engineering schools. It has over 12,000 students enrolled from every State in the Union and from over 80 foreign countries. In addition to its basic educational mission, Georgia Tech supports the entire Southeast United States through an extensive number of research and service projects conducted both on campus and through outreach programs. One education and research area at Georgia Tech that is of particular interest to the subcommittee is with regard to manufacturing engineering. Georgia Tech is the home of a well-established program in computer integrated manufacturing systems. It also is close to dedicating a brand new manufacturing research center. Both of these are key elements in giving Tech its capability in manufacturing engineering education and research.

Testifying with Dr. Thomas is Dr. Kent Bowen of the Massachusetts Institute of Technology. Dr. Bowen is the Ford Professor of Engineering at M.I.T. He is also the co-director of M.I.T.'s Leaders for Manufacturing Program. He recently was appointed to be a member of the Defense Science Board. Dr. Bowen was a member of the M.I.T. Commission on Industrial Productivity and contributed to the commission's study which was documented in the recent book, "Made in America: Regaining the Productive Edge." Recommendations of this study have been taken to heart at M.I.T. and have, as one example, resulted in the establishment of the Leaders for Manufacturing Program. We look forward to hearing Dr. Bowen's description of this program and how it is structured to help America regain its status as a world-leader in manufacturing.

Finally, Professor Henry Yang, who is the Dean of the School of Engineering at Purdue University, will give us his views on this important topic and testify on that school's engineering education programs. Professor Yang's broad expertise in aeronautical engineering has led to his being selected for membership on numerous outside boards and committees, including the Defense Manufacturing Board, the Defense Science Board, the National Science Foundation's Engineering Advisory Committee, the Air Force Scientific Advisory Board, and NASA's Aeronautical Advisory Committee.

Purdue ranks with Georgia Tech and M.I.T. as a top U.S. engineering university and is the home of a national science foundation engineering research center on intelligent manufacturing systems. They also offer a master's degree with emphasis on manufacturing engineering. We look forward to hearing Professor Yang's views on the science and engineering education needs of the country, and especially on the programs that Purdue is pursuing.

Before proceeding, let me defer to a senator from Indiana, Senator Coats, who I understand is not a Purdue graduate, but wishes today that he were. Let me defer to Senator Coats for any statement he has, and then to Senator Nunn for any statement that he has.

Senator Coats. Thank you very much, Mr. Chairman. There are many days I wish I was a Purdue graduate, particularly when I am campaigning over in the West Lafayette area and having to explain why I went to Indiana University instead of Purdue to

Purdue graduates. But I want to also welcome Dr. Yang and other witnesses here this morning. We have a well balanced set of perspectives on the critical issue of the Defense Department's support for scientific, technical, and engineering education programs in the United States that are represented by this panel.

As we have discussed in the context of earlier subcommittee hearings, the recent experiences in Desert Shield/Desert Storm have underscored dramatically the value of technological superiority to our national security. Direct funding of military research and development will not be sufficient to assure our access to the most advanced technology. Rather, we must take additional steps to ensure that we have an abundant supply of scientists and engineers and other technically qualified professionals in both our commercial and defense industrial sectors.

The Department of Defense already spends, as we know, significant sums on programs to support these institutions that will provide that next generation of citizens with degrees in science and mathematics fields. The Department of Defense also supports a large number of R&D facilities, such as the labs that can provide resources to assist these institutions, teaching students in these disciplines at all levels. And I think we need to continue to seek new ways to tap these Defense Department assets.

Our witnesses, as you said, Mr. Chairman, bring many essential perspectives to the issues of where we are today and where we should go in terms of Department of Defense support for these critical areas of education.

Dr. Yang, let me just say welcome to a fellow Hoosier and let me note that Dr. Yang, in addition to being Dean of the School of Engineering, and the Neil Armstrong distinguished Professor of Aeronautics and Astronautics at Purdue, has been at Purdue since 1969. And in addition to the very well recognized publications and other papers, articles that have appeared in scientific journals, he continues to teach. He continues to be there with the students, and that is more important at least to me than any specific award that Dr. Yang has received is the accumulation of 13 awards of outstanding undergraduate teaching, three of which he received after becoming Dean. So he just does not sit in an office and crank out important papers, but he gets down and rolls up his sleeves and works with students. And it is that product which will be his most lasting contribution. So, Dr. Yang, I thank you for that and appreciate your presence here this morning.

Mr. Chairman, thank you.

Senator BINGAMAN. Thank you. Senator Nunn, do you have a statement?

Chairman NUNN. Mr. Chairman, thank you and Senator Coats for holding this hearing on what I think is one of our most important subjects, in terms of both defense and in terms of what you and I have discussed a great deal, our commercial and competitive challenge in the country and how we can look at the two together.

I am particularly proud to have our Georgia Tech representative here today, and as a Georgia Tech drop out, I can attest to the academic rigors going back many years. We are very proud of Georgia Tech and what they have done, and the other schools represented here today.

Senator **Bingaman**. Thank you very much.

Dr. Kimmel, please begin with whatever statement you would like to make.

STATEMENT OF DR. H. STEVEN KIMMEL, DEPUTY DIRECTOR, DEFENSE RESEARCH AND ENGINEERING, PLANS AND RESOURCES, DEPARTMENT OF DEFENSE

Dr. **Kimmel**. Thank you, Mr. Chairman, members of the subcommittee, ladies and gentlemen, I am pleased to testify today on behalf of the Department of Defense on our efforts to strengthen science and engineering education in the United States. With your permission I would like to summarize my prepared statement and have it submitted for the record.

Senator **Bingaman**. We will be glad to include your statement and the statements of the other witnesses today in their entirety. Please begin and summarize in any way you would like.

Dr. **Kimmel**. Thank you, Mr. Chairman. I want to draw your attention to three main points this morning. First of all, I want to emphasize the Department's commitment to strengthening science and engineering education at all levels, and to acknowledge the Department's mandate in this important area of education. Second, we have made headway in addressing areas the subcommittee has highlighted over the past few years, and have numbers and data to illustrate the scope of our responsibilities and our progress. And third, I want to report on our centralized management approach which we believe to be a key to our future progress. Before responding to your questions, let me briefly provide some specifics in each of these areas.

The Department's commitment to improving the science, engineering, mathematics, and technical education within the Nation and the clear mandate to conduct education programs in support of national security missions is manifested in the DOD portion of the FCCSET report on education and human resources. In the introduction to the DOD portion of this report Mr. Cheney states, and I quote, "I want to strengthen and encourage you in your support for the President's efforts to improve the technical education of our youth, the defense of the intellectual base that must go hand in hand with the defense industrial base if we are to succeed."

The succeeding pages of the report document DOD's efforts in all areas related to the interests of this subcommittee this morning, and are included in my written testimony that you have approved for the record.

Approximately 14 percent of all U.S. scientists and engineers are employed in defense activities. Since the DOD relies heavily on a strategy of technological superiority, the Department directly employs more than 100,000 scientists and engineers, and that represents approximately 3 percent of the national labor pool. Of this number, approximately 25,000 are engaged in research and development in the DOD's laboratories and centers. In addition, currently there are more than 9,000 graduate students sponsored through DOD sponsored research and fellowships.

And that brings me to my second point. The Department has a number of special categories of students for whom we have traditionally been responsible, and a number of programs addressing science and engineering education. We have supplied this data to the FCCSET Committee for their report. Some of these categories include the Department's efforts in the Department of Defense dependent schools, where both in the United States and overseas there are more than 200,000 students in the kindergarten through 12 grades. Certainly the service academies, whose total enrollment of 14,000 with nearly 3,300 officers that graduated in 1990, represent a significant investment. And lastly, throughout the land there are students representing a total of 87,000 in various programs of the reserve officers training corps.

These programs represent an extensive array, a decentrally executed program on behalf of the services and defense agencies. They are manifested in the three levels, mostly at the graduate level where we have fellowships, traineeships, research traineeships, research assistantships, military post-graduate training, civilian employee training, and the new careers in education opportunities for those leaving the military services.

That is coupled with our undergraduate programs where we have the co-ops and the laboratory experience opportunities and additional educational training or technology opportunities that try to reach out to minorities, women, and persons with disabilities. Our pre-college programs include our Adopt-a-School, exchange agreements, education partnerships, as well as cooperative programs. The services and defense agencies are actively involved in their local communities through both funded as well as volunteer efforts.

With all this going on, the large number of students involved in such a wide variety of programs, DOD needs an overall management scheme. And that is why the Deputy Secretary of Defense, in responding to the Fiscal Year 1991 Authorization Act, designated the Director of Defense Research and Engineering as that central authority and tasked him to develop this management plan.

Our next step then, and the third point I wish to emphasize this morning, is the management plan and the subsequent action that we anticipate. The plan is in process now. It is the first time the Department has addressed its many activities and tried to put it together in some sort of integrated fashion. The purposes are threefold, to establish DOD science and engineering educational activities in their proper position as part of the DOD and of course the Nation's priorities, policies, and plans; to articulate the educational goals and objectives in scientific and engineering education for the Department of Defense under the leadership of the Director of Defense Research and Engineering; and to outline a management structure and to identify the management relationships that will provide for development and execution within the Department of a series of science and engineering education action plans that will achieve DOD's priorities.

The goals are just a few, but they are very important. To assure an adequate supply of capable scientists and engineers to meet the needs of national defense, and to support the national education goals and the educational goals of the national technology policy where their goals overlap the DOD mission.

Our objectives are six in number, as proposed in the plan being circulated for coordination as I speak. To improve the quality of pre-college science and mathematics education and of undergraduate and graduate education in science and engineering fields important to national defense; second, to stimulate and encourage a greater number of American young people to continue their studies in science and mathematics and to consider careers in science and engineering; third, to continue support for undergraduate, graduate, and post-doctoral education in science and engineering fields important to the long-term Department of Defense needs; fourth, to help recruit and retrain scientists, engineers, and technical personnel of the highest quality for the DOD work force; fifth, to provide continuing scientific, engineering, and technical education or training needed for DOD personnel, civilian or military, to sharpen existing skills, acquire new skills, and develop full professional potential; and lastly, to increase the participation in science and engineering professions among members of underrepresented minorities, women, and handicapped persons.

As for the action that we have directed to date, the most significant is that the Director of Defense Research and Engineering has directed the services and defense agencies to implement the statutory authority and responsibilities that your committee put forward in the fiscal year 1991 Defense Authorization Act. This includes the delegation of authorities for lab directors to establish cooperative work education programs and to enter into partnerships with local institutions, as well as to provide infrastructure support to historically Black colleges and universities and minority institutions, to name a few.

The services are now in receipt of that direction and the authorities, and have begun to implement it. We expect to hear from the services within 120 days of the details and progress, and to begin then finalizing our management plan and actions.

In summary, the Department of Defense will play a major role in our Nation's quest for improving science and engineering education, but first we will seek better coordination and assessment of DOD's many complex science and engineering education activities while retaining decentralized execution. The challenge is to guard against creating administrative overload and destroying flexibility and creativity, especially in the volunteer efforts, while still providing program coherence and direction.

Since this is the first coordinated DOD management effort in science and engineering education, merely finding out who is doing what and how much and what the various programs cost is a huge effort. We are still at the beginning stages of coordinating, evaluating, and managing more effectively, but we are making progress.

With that I would be happy to answer any questions.

[The prepared statement of Dr. Kimmel follows:]

PREPARED STATEMENT BY DR. H. STEVEN KIMMEL, DEPUTY DIRECTOR DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE

Mr. Chairman, members of the committee, ladies and gentlemen. I am pleased to testify on behalf of the Department of Defense (DOD) on our efforts to strengthen science and engineering education in the United States.

The Department of Defense is deeply interested in the vitality of science and engineering education in this country. The notable performance of U.S. forces during the conflict in the Persian Gulf verified our investments in intensive, specialized training of our service members. At the same time, the fine performance of American weapon systems and platforms verified past investments in the education of the scientists and engineers who developed that technology. We must train the next generation of scientists and engineers if we want our Armed Forces to continue to have the superior technology that has been a key element of U.S. military strategy since World War II. Better technology helps our forces deter armed conflict and gives them an edge over potential adversaries, should deterrence fail.

DOD science and engineering education supports not only these national security goals but also goals stated in U.S. technology policy and education policy. In the area of technology policy, DOD supports two major elements: the effort to revitalize science and engineering education at all levels and Federal investment in basic research, especially at the university level, which produces trained scientists and engineers in addition to new knowledge.

The two National Education Goals established by the President and the Nation's Governors at the 1989 education summit that relate most directly call for, by the year 2000:

- U.S. students leaving grades 4, 8, and 12 to have demonstrated competency in challenging subject matter including mathematics and science.
- U.S. students to be first in the world in science and mathematics achievement.

The Department is spending more than a billion dollars this year on science and engineering education. About one-third of that amount is for activities where science and engineering education is the principal reason for our investment. An example is fellowships for science or engineering graduate study. The rest of the dollars are in educational portions of research programs and in science and engineering portions of general education programs like those at the service academies. In spite of extensive cuts throughout the defense budget, funding for science and engineering education remains fairly stable when we compare the fiscal year 1991 appropriated dollars to the President's budget request for fiscal year 1992.

GRADUATE EDUCATION IN SCIENCE AND ENGINEERING

DOD is probably best known on university campuses around the country for its support of graduate education, something we have done through our university research programs for 45 years. Concerned that we needed to do more to increase the quality and quantity of U.S. scientists and engineers, the Secretary of Defense stated in the late 1970s that DOD would increase university participation in its research programs. As funding for university research grew faster than that for other portions of the research program, the number of DOD-supported graduate students jumped from a little over 5,000 in 1980 to well over 9,000 in 1989, an 80 percent increase. We are proud of that.

We are also proud that DOD supports more graduate students in engineering than any other Federal agency. DOD accounts for about half of the Federal Government's total support for graduate students in electrical engineering, computer science, and industrial engineering.

Engineering education is especially important in light of recent concern that American research and development (R&D) may not be translating research results into products and processes rapidly enough. DOD's primary interest is in the defense sector, where applying technology quickly is essential to our military competitiveness. But the timeliness of applying technology is also important in the commercial sector, where it bolsters U.S. economic competitiveness. This is an area that this subcommittee has expressed a good deal of interest in.

UNDERGRADUATE EDUCATION IN SCIENCE AND ENGINEERING

DOD's primary dollar investment in undergraduate science and engineering education is in programs for future military officers. In fiscal year 1991, DOD is investing about $300 million to educate 22,000 future scientists and engineers in the service academies and through the Reserve Officers' Training Corps.

The military departments, the National Security Agency, and the Defense Mapping Agency promote undergraduate education in three other types of programs. First, they conduct a variety of activities, such as cooperative-work education, that give undergraduates research experience during summers and other vacation periods. Second, they run programs to encourage more minorities to pursue careers as scientists and engineers. Third, they conduct job-related training to help DOD employees realize their full potential and enhance their performance.

More information about these programs is contained in the fiscal year 1992 report of the Committee on Education and Human Resources. That committee was formed by the President's science advisor under the Federal Coordinating Council for Science, Engineering, and Technology, or FCCSET. I have attached a copy of the DOD chapter from the FCCSET report to my statement and ask permission to have it incorporated into the record.

PRECOLLEGE EDUCATION IN SCIENCE AND MATHEMATICS

DOD wholeheartedly agrees with the priority that the FCCSET committee assigned to precollege education. Without a solid foundation at the precollege level, we can achieve only limited success in meeting our objectives for future scientists and engineers through action at the undergraduate and graduate levels.

Most DOD funding for precollege education is through the DOD Dependents' Education System. About 200,000 young Americans are educated in this system, which is comprised of 270 schools overseas and 67 schools in this country. The mathematics and science portion of the schools' budget is about $300 million.

The dependents' schools are in the vanguard among school systems in establishing measurable objectives to meet the National Educational Goals set by the President and the Governors. In line with the goal of making American students first in the world in science and mathematics achievement by the year 2000, the dependents' schools set specific targets for improving science and mathematics scores on standardized achievement tests. (Note that scores in the DOD schools are currently better than national averages.)

Furthermore, the schools are retraining thousands of mathematics teachers in the new curriculum and evaluation standards advanced by the National Council of Teachers of Mathematics, widely recognized as the best standards available. The schools are looking at revising science curricula, too, to reduce emphasis on learning facts and increase emphasis on problem solving and on current science and technology topics to capture students' interest.

While the DOD dependents' schools account for most of the Department's funding in precollege education, that large dollar investment is only part of the story. There are many local efforts by defense laboratories and organizations that provide some dollars and a lot of volunteers. For example, officers and enlisted personnel from the Naval Military Personnel Command are tutoring young students from the inner city here in Washington. Army and Navy laboratory personnel donate their time generously to local schools for science fairs, guest classroom lectures, and tutoring of individual students. These are grassroots efforts by talented, dedicated citizens serving their local communities.

President Bush recently visited a minority-oriented education partnership program at the Naval Academy in Annapolis. Seventy midshipmen give up time on their only free day of the week to tutor and serve as mentors to 150 students in grades 5-12.

We must not underestimate the importance of the hundreds of efforts like these that go on at DOD activities around the country. They underscore the need for good management of science and engineering education within the Department. We need management that provides leadership and direction. We also need management that does not stifle the enthusiasm, creativity, and initiative of thousands of DOD scientists and engineers who want to contribute their time and energy locally to help address the national need.

DOD MANAGEMENT OF SCIENCE AND ENGINEERING EDUCATION

Having said that, I would like to talk about what we are doing to improve DOD management in this area. This subject received a good deal of attention during your hearing on science and engineering education last year. This February the Secretary of Defense designated the Director of Defense Research and Engineering (DDR&E) as the individual within the Office of the Secretary of Defense to advise and assist the Secretary regarding matters relating to science, mathematics, and engineering education and training.

Shortly thereafter, the DDR&E directed the military departments and pertinent Defense Agencies to implement new statutory authorities and responsibilities that your committee put forward in the Fiscal Year 1991 DOD Authorization Act. The DDR&E's directive gives laboratories the responsibility to establish cooperative work-education programs and authority to enter partnership agreements with educational institutions. It also transmits the responsibility to provide infrastructure support to historically Black colleges and universities and to other minority institutions. The DDR&E gave DOD components 120 days to implement these statutes; so we expect to be able to give you a better picture of DOD actions in this regard by mid-summer.

To establish the needed leadership in science and engineering education, the DDR&E also directed the preparation of a management plan for this area. Although that plan has not yet been approved, we anticipate that it will help us determine the kinds of DOD activity and levels of effort required to meet long-term defense needs. We also expect that it will help us make the best use of available DOD resources, both financial and human resources, toward meeting those needs.

The plan should improve coordination among the many DOD organizations that are involved in science and engineering education. To prevent stifling local initiative, of course; the plan will provide decentralized program execution except in the few cases where centralization would prevent wasteful administrative costs.

SUMMARY

DOD is strongly committed to addressing long-term defense needs for scientists and engineers in addition to addressing pertinent national education and technology goals. I am pleased that I had this opportunity to report some of the many good things that DOD is doing in this regard. Even so, we are not yet satisfied that we know whether we are doing enough or whether we are doing everything as well as we can.

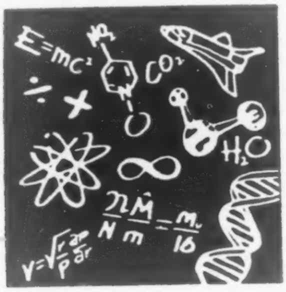
I believe that the management plan we are preparing will help us improve that situation. We expect to be in a better position to judge the appropriateness and adequacy of our programs by early next year, when we begin to review the Six-year Defense Program for 1994-1999. That is not as soon as some of us might like, given that we all share a sense of urgency in addressing the national needs; but we must do the job right, as well as quickly.

Finally, if we are to achieve the national goals in science and engineering education, many people in many organizations will have to work together. They include the other Federal agencies with whom DOD is now working closely in the FCCSET. They also include the private sector and State and local governments, with whom we will be working more in the future. And, of course, the Congress plays an important role. We stand ready to work constructively with you again this year in pursuit of our mutual interests and common goals.

THE U S DEPARTMENT OF DEFENSE

"I want to encourage you in your support for the President's efforts to improve the technical education of our youth—the defense of the intellectual base that must go hand-in-hand with the defense industrial base if we are to succeed."

Richard Cheney
Secretary of Defense

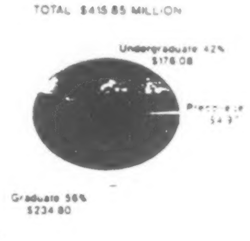


pages 93-110 from
By the Year 2000: First in the World,
Report of the Committee on Education and
Human Resources,
Federal Coordinating Council for Science,
Engineering, and Technology

SCIENCE AND ENGINEERING EDUCATION IN THE DEPARTMENT OF DEFENSE

Approximately 14% of all U.S. scientists and engineers are employed in defense activity. Since the Department of Defense (DOD) relies heavily on a strategy of technological superiority, the Department directly employs more than 100,000 scientists and engineers, approximately 3% of the national pool. Of this number, approximately 25,000 are engaged in research and development in DOD laboratories and centers. Nine thousand graduate students every year are supported through DOD-sponsored research and fellowships. The DOD has a vital interest in the ability of our Nation's colleges and universities to produce highly trained scientists and engineers.

A number of factors may affect DOD's future ability to recruit and retain qualified scientific and technical personnel. Chief among the concerns are changing demographics that will markedly affect the composition of the work force. It is estimated that by the year 2000, 85% of the increase in new entrants to the work force will be women, minorities, handicapped persons and immigrants, groups which traditionally have chosen careers other than science and engineering.



DOD Education Budget FY 1992

This year, the DOD authorization act directed the Secretary of Defense to designate an individual within the Office of the Secretary of Defense to advise on science, mathematics and engineering education. The act also authorized DOD laboratories to enter into partnerships with schools in which surplus equipment can be donated, allow DOD personnel to teach and advise students, and allow students to work in DOD facilities. These facilities employ scientists and engineers from a wealth of disciplines and provide a multidimensional educational resource.

DOD has a clear interest in and concern for maintaining an adequate supply of well-trained scientists and engineers; however, its courses of action to address this issue must be consistent with the mission and statutory authority of the DOD. The Department of Education and the National Science Foundation have a major mission and a clear mandate to develop and conduct programs in science and engineering education. The DOD mission is to provide for national security, and any education programs it conducts must be in support of that mission.

DOD already makes a major investment in education and training. In the traditional educational setting, DOD provides education for grades K-12 for 200,000 dependents in overseas locations through the Department of Defense Dependents School System (DODDS) and in U.S. locations where the local civilian schools cannot meet the needs of the dependent population. The Service Academies, with a total enrollment of 14,000, will graduate about 3,300 officers in 1990. ROTC programs enroll about 87,000 with 21,740 on scholarships. Over 750,000 enlistees are participating in the Montgomery GI Bill plan, which provides subsidies to assist them in completing their college educations. These activities are representative of DOD education and training activities for military personnel, but they are concerned only in part with science and engineering education.

Science and Engineering education activities in DOD include undergraduate Reserve Officer Training Corp (ROTC) scholarships, graduate fellowships, conduct of research by graduate students in support of national defense, and programs designed to enhance recruitment and retention of civilian employees in science and engineering career fields.

The Service research programs are coordinated for the Secretary of Defense by the Office of Research and Laboratory Management. DOD also coordinates with other agencies, such as the National Science Foundation, Department of Energy, National Aeronautics and Space Administration, and National Institutes of Health, to assure that stipends are comparable, policies are uniform, and common problems are recognized. The Office of Personnel Management coordinates all Federal personnel programs but each organization may emphasize different programs to fit its needs. Equal Employment Opportunity (EEO) guidelines are likewise established government-wide.

ONGOING PROGRAMS

The Department of Defense supports a wide variety of science and engineering education programs. Some provide direct student support, in the form of fellowships for students or tuition payments for employee training; others provide indirect support, such as work experience in DOD laboratories or research performed through DOD grants to universities. Table 1 is a list of DOD laboratories. There are over 60 of these facilities in 20 States. DOD programs encompass all levels of education from precollege to postdoctoral, with the greatest support at the graduate level. Programs include both training for Department civilian employees and broader educational efforts to increase the supply of scientists and engineers. Science and technology education activities in the military Service academies, Service postgraduate schools, technical training schools, and education programs for Service personnel are substantial and do include a science and engineering component.

Program descriptions are categorized by the education level (precollege, undergraduate, graduate, and postdoctoral). The programs are then further characterized by the primary purpose. Unless specifically stated to the contrary, U.S. citizenship is a requirement to participate in all these programs.

Precollege

Programs to Improve the Quality of Science Education:

The National Science Resources Center (NSRC) is sponsored by the National Academy of Sciences and the Smithsonian Institution. DOD has provided approximately one-third of the funding for a study to examine factors that improve the quality of science teaching at the elementary school level. The first three years of this five-year program have focused on identifying school systems with exemplary science programs, collecting science resource materials; disseminating information on science resource materials through a network established by NSRC; developing instructional materials for three critical science concepts; field testing these materials; and conducting training workshops for elementary

Facility	**Location**	**Affiliation**
Aeromedical Research Laboratory	Ft. Rucker, AL	Army
Missile Research, Dev. and Engr Cntr	Huntsville, AL	Army
Aviation Research and Technology Activity	Moffett Field, CA	Army
Letterman Army Institute of Research	Presidio, SF, CA	Army
Biosciences Laboratory	NSC Oakland, CA	Navy
Civil Engineering Laboratory	Port Hueneme, CA	Navy
Health Research Center	San Diego, CA	Navy
Ocean Systems Center	San Diego, CA	Navy
Personnel Research & Development Cntr	San Diego, CA	Navy
Weapons Center	China Lake, CA	Navy
Astronautics Laboratory	Edwards AFB, CA	Air Force
Frank J. Seiler Research Lab	USAFA, Col Spngs, CO	Air Force
Submarine Medical Research Laboratory	Groton, CT	Navy
Institute of Dental Research	Washington, DC	Army
Walter Reed Army Institute of Research	Washington, DC	Army
Naval Research Laboratory	Washington, DC	Navy
Aerospace Medical Research Laboratory	Pensacola, FL	Navy
Armament Laboratory	Eglin AFB, FL	Air Force
Engineering and Services Laboratory	Tyndall AFB, FL	Air Force
Construction Engineering Reaserch Lab	Champaign, IL	Army
Dental Research Institute	NTC Great Lakes, IL	Navy
Biodynamics Laboratory	New Orleans, LA	Navy
Atmospheric Sciences Laboratory	White Snds Msl Rng, NM	Army
Ballistic Research Laboratory	APG, MD	Army
Biomedical R&D Laboratory	Ft. Detrick, MD	Army
Chemical Rsch, Dev and Engr Cntr	APG, MD	Army
Engineer Waterways Experiment Sta	Vicksburg, MD	Army
Harry Diamond Laboratories	Adelphi, MD	Army
Human Engineering Laboratory	APG, MD	Army
Materials Technology Laboratory	Watertown, MA	Army
Medical Research Inst of Chemical Defense	APG, MD	Army
Medical Research Inst of Infectious Dis	Ft. Detrick, MD	Army
Natick Research, Development & Engr Cntr	Natick, MA	Army
Rsch Inst of Environmental Medicine	Natick, MA	Army
Tank Automotive RD&E Center	Warren, MI	Army
Clothing & Textile Research Facility	Natick, MA	Army
David Taylor Ship R&D Center	Bethesda, MD	Army
Medical Research Institute	Bethesda, MD	Army
Ocean R&D Activity	Bay St. Louis, MO	Army
Geophysics Laboratory	Bedford, MA	Air Force
Armed Forces Radiobiology Rsch Institute	Bethesda, MD	DoD
Armament Research, Development & Engr Center	Picatinny, NJ	Army
Avionics R&D Activity	Ft. Mommouth, NJ	Army
Center for Electronic Warfare	Ft. Mommouth, NJ	Army
Cold Regions Research & Engr Lab	Hanover, NH	Army
Electronic Technology & Devices Lab	Ft. Mommouth, NJ	Army
Air Propulsion Center	Trenton, NJ	Navy
Rome Air Development Center	Griffiss AFB, NY	Air Force
Weapons Laboratory	Kirtland AFB, NM	Air Force
Aero Propulsion Laboratory	WPAFB, OH	Air Force
Aerospace Medical Research Laboratory	WPAFB, OH	Air Force
Avionics Laboratory	WPAFB, OH	Air Force
Flight Dynamics Laboratory	WPAFB, OH	Air Force
Materials Laboratory	WPAFB, OH	Air Force
Underwater Systems Center	Newport, RI	Navy
Institute of Surgical Research	Ft. Sam Houston, TX	Army
Human Resources Laboratory	Brooks AFB, TX	Air Force
School of Aerospace Medicine	Brooks AFB, TX	Air Force
Belvoir RD&E Center	Ft. Belvoir, VA	Army
Center for Night Vision & Electro-Optics	Ft. Belvoir, VA	Army
Center for Signals Warfare	Warrenton, VA	Army
Engineer Topographic Laboratories	Ft. Belvoir, VA	Army
Rsch Inst for Behavioral & Social Sciences	Alexandria, VA	Army

Table 1

Lt. Lynn Title tutors an inner city student as part of the "Navy Kids" Washington program. Title is assigned to the Naval Military Personnel Command.

science teachers. The field testing was conducted at 21 elementary schools in 13 school systems including DOD Dependents Schools in the Philippines and several schools with large black or Hispanic student populations. A workshop was conducted in 1987 for participants representing 13 school systems with a combined enrollment of over 500,000 students.

Another program that addresses the quality of science and technology education is the Army High School Science and Mathematics Faculty Program, administered by the Army Research Office. This program provides six to ten weeks of experience in an Army laboratory for high school faculty members. The experience is intended to foster an appreciation for the professional challenges faced by scientists and engineers; an exposure to current state-of-the-art research topics; and hands-on experience with modern research instruments. The program is conducted at 30 Army laboratories at various locations around the country during the summer months.

Programs to Stimulate Interest in Science and Technology Careers

Programs in this category are intended to capture the interest of students at an early age by making them aware of science activities and providing them with information on career opportunities in science and technology. Many programs expose students to science activities through tours of DOD laboratories and centers, classroom lectures by DOD scientists and engineers in the school, and other creative use of DOD scientists. Because of the varied nature of these activities, data are generally not available on the numbers of participants or the funds expended in these programs.

The Army and Navy, through the Army Research Office and the Office of Naval Research respectively, have made a concerted effort to stimulate and encourage the technical development of our Nation's youth through involvement in the national science fair program, which typically attracts about 100,000 students annually. The Army Science Fair Program awards first and second place prizes at each of 350 State and regional science fairs and in a national fair. The Navy Science Awards Program follows a similar format.

An example of a more structured approach to these activities is the Adopt-A-School Program carried out by many DOD facilities. In these programs DOD employees volunteer to support the school by tutoring students; providing assistance on math and science research projects; judging science fairs; participating in career day presentations; lecturing on math, science and technology subjects; hosting Honors teas for students and parents; instructing students and staff on the use of computers in science and math; and serving as mentors for students. Adopt-A-School programs were established in 1983-84 in many locations following a memorandum from President Reagan to the Federal departments and agencies. Vigorous Navy programs were established in the San Diego and Great Lakes areas in 1984.

Yeoman 2nd Class G. E. Simpson tutors an inner city student as part of the "Navy Kids" Washington program. Simpson is assigned to the Naval Military Command.

A more comprehensive stimulation program is the Junior Science and Humanities Symposium, the first and largest precollege program sponsored by DOD. Initiated in 1957 and administered by the Army Research Office, the program consists of two to three-day regional meetings which include presentations of papers on research performed by the students; tours of research facilities; a keynote talk by a prominent scientist; discussions on current issues in science; career guidance; and discussions on the relationship of science to the humanities. The program reaches approximately 10,000 students and 250 teachers annually. Ninety-eight percent of the participants go on to college.

The Texas Pre-Freshman Engineering Program (TEXPREP) is similar in scope but was established by a consortium of State and local governments, colleges and universities, Federal agencies, and private industry in the State of Texas. The program provides academic instruction, tours and presentations on science and engineering subjects to students in grades 6-11 who have high potential for science or engineering careers. The program has a high percentage of women and minority participants (91% in 1989) and has had an outstanding success rate in encouraging students to attend college (90%); 60% of those attending college pursue careers in science and engineering.

Programs Targeted on Minorities, Women and Persons with Disabilities

Activities pursued in this category are very similar to those described above but are targeted on women, minorities, and handicapped persons, groups which are traditionally less likely to pursue careers in science or engineering.

The Uninitiated Introduction to Engineering (UNITE) Program, administered by the Army Research Office, provides a four-week intensive experience, primarily for minorities (98%), but also for other disadvantaged youths. The programs are conducted at eight universities across the U.S. and consist of academic instruction on trigonometry, pre-calculus, computer science, physics, chemistry, and communication skills.

Other examples of successful precollege programs conducted at the local level include the Minorities in Engineering and Handicap Outreach Programs conducted by the Naval Air Development Center (NADC) in Warminster, Pennsylvania. The Minorities in Engineering Program consists of two-hour sessions held every two to three weeks during the school year at NADC. The sessions include an introduction to digital electronics: computer programming: career workshops and college information: a tour of the center: and a student project. Students are drawn from four local high schools. based on interviews and recommendations of science teachers. The program is targeted for minorities and conducted by the EEO office. but others are not excluded.

The Handicap Outreach Program targets junior and senior high students with a disability and involves tours of NADC and establishment of a mentor relationship with NADC employees with a similar handicap. The Technical Mentor program at the Naval Weapons Center is intended to provide support to women. minorities. and economically disadvantaged youths who are underrepresented in science and engineering. The program starts with high school juniors who perform educationally related tasks in an unpaid status under the student volunteer program. During their senior year these students are hired for a year as student aides under the Stay-in-School program.

Programs to Provide Work Experience in DOD-Funded Research

The goal of these programs is to stimulate interest in science and engineering careers through a hands-on work experience in a DOD-funded laboratory and through a mentor relationship with an active scientist. Under the DOD Science and Engineering Apprenticeship Program for High School Students. students work on research projects in DOD Laboratories or with principal investigators at universities who have DOD research contracts or grants. Since 1981. when the program was concentrated primarily in the Army and Navy laboratories in the Washington. D.C. area. this initiative has grown to include participation by all three Services. The Office of Naval Research administers the local program for the Washington. D.C. area on behalf of the Army and Navy laboratories in the area. via a contractor that provides for recruits. screens and matches student apprentices with laboratory mentors. The program placed 667 participants in 24 laboratories and organizations in the Washington-Annapolis area in 1989 for a period of ten weeks during the summer. Teachers can also participate and earn credit with additional weekend lectures prior to the start of the student program. Students and teachers work on real research projects in DOD labs under the tutelage of DOD civilian scientists. The students and teachers prepare reports on their projects and present the results in a staff seminar. Teachers monitor and coordinate the activities of the students. The Air Force has a similar program for students in the Dayton. Ohio area called the High School Apprenticeship Program. There were 103 participants in 1989 in the Air Force program.

NRL's commanding officer. Capt. John J. Donegan. Jr.. visits the Young Astronauts Club of Woodlawn Elementary. Woodlawn. VA and discusses agency space research

The High School Apprenticeship and Research and Engineering Apprenticeship (REAP) programs are sponsored respectively by the Office of Naval Research and the Army Research Office. These initiatives provide research experiences for high-potential high school students in an academic environment. Students are placed with Principal Investigators on DOD research grants and are paid minimum wages during the work period. During 1989 the Navy had 80 apprentices and the Army had 110 at 56 institutions. Surveys indicated that 85% of the REAP students attended college.

The NRL Gifted and Talented Program and the Naval Coastal Systems Center Gould Science Award provide work experiences for students over an extended period of time. The Gifted and Talented program of the Fairfax County Public Schools allows high achievement students in their junior and senior years to work in local industry and government facilities. The Gould Science Award is given to the top science students in three of the NCSC area local high schools, and the students are offered a summer appointment following their senior year.

Students with less experience, such as junior high school students, may be allowed use of government facilities for Student Volunteer Services. OPM has relaxed the age limit for the student volunteers to allow 14 and 15-year-olds to participate, as long as there is no conflict with State and local child labor laws.

Undergraduate

The main purposes of DOD support for undergraduate science and education programs are to ensure a supply of college graduates trained in science and engineering for the Services; to offer work experiences for students that may assist in recruiting; and to provide job related training for full-time employees. The largest undergraduate program is the ROTC program, which in recent years has selectively sought science and engineering majors. Several of the older summer programs such as Stay-in-School, Federal Junior Fellow, and Summer Aid were conceived as means to supplement the incomes of students from low-income families who would otherwise not be able to attend college. The Cooperative Education (Co-op) program provides on- the-job work experience and an income supplement interspersed with full-time academic periods. The newest undergraduate programs are targeted on increasing the number of minority students pursuing careers in science and technology.

Scholarship Support Programs

All three Services operate ROTC programs at cooperating universities nationwide. Eight hundred fifty universities have an ROTC affiliation, and 87,000 students participate in ROTC training, most in non-scholarship status. The ROTC program was initiated in 1916 under the Morrell Act, but since 1964 the program has been refocused to emphasize scholarship support and active recruitment of science and engineering majors. The Air Force program in particular recruits 70-80% science and engineering majors. The Services had a total of 21,739 participants on scholarships in 1989. Approximately 60% were majoring in science, math and engineering fields. Scholarship support of tuition, books, fees and monthly stipends of $100 are paid during the school year, and summer training and cruises bring the total support to approximately $8,000 per year. Total support for the science and engineering scholarships amounted to $105 million in

1989. The graduates are obligated to four years active duty military service but may be commissioned in the reserves depending on force requirements.

The Army has developed the Science and Engineering ROTC Co-op program, as an alternative to the basic ROTC program, to recruit scientists and engineers. Students must be enrolled at one of the 145 participating universities that offer a science and engineering curriculum, an Army ROTC program, and have a Co-op program. The students are eligible for up to $5,000 per year for tuition, fees, and room and board. Participants are also offered co-op jobs at an Army laboratory with additional pay for the work period. Upon graduation, the students are commissioned in the Army Reserves and are obligated to work at an Army laboratory until a service commitment is met. The program was adopted permanently and transferred to the Army Personnel Command for administration. Initial efforts to recruit for active duty service were not as well received as the Reserve status. The program currently has over 200 participants.

Programs to Provide Research Experience

Co-op programs, to provide alternate periods of work experience at DOD facilities and academic education, are available at many universities and colleges. The program is usually open to sophomore or junior level students meeting certain academic standards. The program helps students make more informed choices of career specialties and supplements to their income. The program has proven to be an effective recruitment method for undergraduate personnel and provides an opportunity to evaluate a potential employee's abilities before hiring. Students in the undergraduate program are permitted up to 1,040 hours of work per year at a GS-2 or 3 level, consistent with their qualifications. Students may be converted to career conditional appointments upon graduation.

The Stay-in-School program supplements income for students who would have difficulty otherwise meeting the financial burdens of a college education. The need requirements for admission to the program are established annually by OPM. The program permits high school and undergraduate college students to work up to 20 hours per week during the school year and full-time during summer and holiday vacation periods, not to exceed 1,040 hours per year. Appointments are for a period of one year but may be extended for additional periods not to exceed one year. Defense Mapping Agency and Naval Coastal Systems Center participate in this program. The Federal Junior Fellow program is somewhat similar to the Stay-in-School program but also has a merit requirement: in addition to having financial need, students must be in the top 10% of their classes. Students are appointed upon graduation

Mr. Kenneth McGrath of NRL's Chemistry Division instructs visiting summer high school students Richard Olson and Melanie Staples on the operation of a nuclear magnetic resonance spectrometer from high school and work the summer after graduation and succeeding summers and vacation periods while in college. Students are eligible for non-competitive appointment to career conditional positions upon receipt of their degrees. Defense Mapping Agency, Naval Research Laboratory, Naval Air Development Center, and the Naval Coastal Systems Center participate in the program.

The Naval Research Laboratory hires approximately 80 college and high school students as research aides during summer and holiday breaks or intermittently during the year. The total hours cannot exceed 1,040 per year—hence the name of the program, 1040 Hour Appointment.

The Summer Aid program provides job experience for needy youths through summer employment and allows reappointment of those with satisfactory performance. Applicants must be referred by a State employment agency and are ranked in order of need. Defense Mapping Agency and Naval Electronic Systems Engineering Activity use the program.

The Summer Hire program of the Naval Research Laboratory and S&E Summer Employment program of the Naval Air Development Center are highly competitive merit programs that provide summer work experience for students in disciplines of interest to the agency. The National Security Agency conducts a similar Summer Program.

Programs Targeted to Increase Participation of Minorities in Science and Technology Careers

Executive Order 12320 in 1980 and Executive Order 12677 of April 28, 1989, provided for the establishment of programs to strengthen the Historically Black Colleges and Universities (HBCUs) by providing assistance and advice to faculty and training opportunities for their students. A number of programs such as the HBCU initiative and Adopt-a-College have been developed in response to the Executive Order. Most use the authorities for student employment and OPM excepted service schedules, but are specifically targeted on the HBCUs. The Office of Naval Research (ONR) has developed a comprehensive program to address both the availability of students and faculty research. The Naval Oceanographic Research Center has established an Adopt-a-College program with Jackson State University and provides summer job opportunities in science and engineering disciplines for undergraduate and graduate students and faculty members. The Naval Air Development Center has targeted about a dozen schools with black and Hispanic populations that conduct engineering programs; different NADC departments have adopted schools, establishing communication on NADC career opportunities. Students participate in two-day visits to NADC, co-op programs and

Dr. Noel Turner of NRL's Chemistry Division explaining the operation of an x-ray photoelectron spectrometer to visiting summer high school students enrolled in Prince Georges County Community College "Young Scholars Instrumentation Institute."

faculty work in summer research programs. Defense Mapping Agency is developing a program which will include summer programs, co-ops, and faculty exchange and provide HCBU's with excess equipment and opportunities to bid on research contracts.

The ONR HBCU program currently provides $3.9 million per year in research and scholarship support to HBCU's. Six additional grants, totaling $14 million over a five-year period, were announced in 1989. The grants fund a spectrum of programs, including direct scholarship and research assistantship support to more than 100 undergraduate students; faculty research grants; student summer research experiences; visiting scholars; and improved laboratory training. Each of the schools is expected to complement the ONR support with its own programs to stimulate interest and improve teaching of science and engineering in grades K-12. The ONR program attempts to reduce attrition in science and engineering majors at the undergraduate and graduate levels.

The National Security Agency conducts a unique Undergraduate Training program for minority students to provide educational and conditional employment opportunities. The program requires an SAT score of 1100, a GPA of 3.0 and an interest in science and math fields of interest to NSA. The program pays tuition, and the student incurs an obligation of one and one-half years of service for each year in the program. The program is slated for expansion to 50 participants in 1990.

Programs to Provide Job-Related Training for Employees

The DOD makes a significant contribution to education in science and technology fields by programs provided for its own employees, who comprise 3% of the national pool of scientists and engineers. Training may be full-time or part-time, on or off-duty, day or evening. It may be provided by the agency itself, an educational institution, another Federal agency, a professional association, or a manufacturer. DOD agencies may pay for all or part of the expenses of authorized training. The training must be in fields that are or will be directly related to the performance of official government duties. Training covers many activities, such as attendance at conferences and short courses. This chapter reports only those training activities that provide formal educational course work in science, math, or engineering disciplines at an accredited academic institution (or DOD Agency programs of equivalent stature). Most training programs apply equally to undergraduate and graduate course work.

The Naval Air Development Center offers a Part-Time Undergraduate Study Award program for non-science and non-engineering employees who wish to pursue a scientific or technical degree. The employee must have already completed one full academic year in the subject field and have career status (three years government service) with one year employment at NADC. Participants may take up to 20 hours education per week at a local college or university, and the program provides full pay, tuition and academic fees. Appointment to the program is for one year, renewable until the Bachelor of Science degree is granted. An obligation of three years service for each year of training is incurred. The Undergraduate Academic program of the Naval Ocean Systems Center offers a very similar program except it is limited to nine credit hours per semester and applies only to upper division courses. The National Security Agency offers an

Advanced Studies program on a 20 hours study 20 hours work format.

The National Security Agency also offers an After-Hours College program that covers up to eight credit hours per semester at a local college in job-related undergraduate and graduate level courses. The Defense Nuclear Agency also has a similar program for off-site educational opportunities for employees.

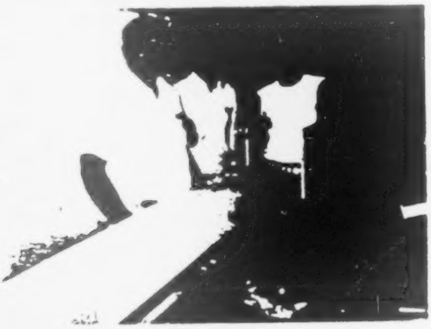
The National Security Agency is also authorized to operate the National Cryptologic School to provide specialized education and training for employees in computer science, electronic engineering, cryptology and related fields. The courses are at undergraduate and graduate levels and are taught during duty hours.

Most components of the DOD offer long-term, full-time training programs that permit residence at a college or university campus, primarily at the graduate level. The Defense Mapping Agency offers its long-term, full-time training program to full-time permanent employees with two years continuous service, a top secret clearance, high potential, and relevant academic background. The employees must pursue training in cartography or related disciplines; be willing to relocate; and incur a three-year service obligation for each year of training. In 1989, four of 35 participants were enrolled in undergraduate education programs. The Naval Weapons Center and the Air Force offer a long-term training program similar to the one above but concentrated in science and engineering fields, without the requirement for the TOP SECRET clearance and willingness to move. The National Security Agency offers an external training program called the Directed Fellowship/ Scholarship program similar to the above programs.

Another special training program is the Career Intern program, which rotates job assignments for entry level personnel in administrative, professional and technological fields who are on management or executive track. Participants may also receive some educational training. Career Intern participants enter at GS-5, 7 and in some cases 9 level and generally reach the full performance level over a period of several years. Career Interns are often recruited directly out of college. Finally, the National Security Agency offers two programs intended to fill shortages of skilled personnel below the B.Sc. level. The Grow Your Own program addresses the need for technicians in collection operations, signals conversion, telecommunications , traffic analysis and computer operations. Program recruits, who are high school graduates and agency employees, receive a combination of formal and on-the-job training. Program graduates must spend two years in the field for which they trained. The Computer Operations Associates program is targeted on community college students in computer science, data processing or computer operations programs. The students are partially supported for continuing educational programs at universities and on-the-job training programs that lead to an Associate degree and qualification for a GS-5 or 7 position.

Graduate

Graduate level education receives the most support from DOD and is focused on the physical sciences, engineering, and mathematics. Skills in these disciplines are crucial to the accomplishment of the Department's mission. The graduate level programs include direct fellowship support, indirect support through research grants to universities, which provide research assistantships for graduate students; and training programs for DOD employees.



Dr. Lloyd Hillman, SFRP from Cornell University, and his graduate students, Mr. Stephen McClain and Ms. Mojdeh Anderson, in the Nonlinear Optics Laboratory at the Frank J. Seiler Research Laboratory

Programs to Provide Educational Support through Fellowships

In 1989 DOD provided fellowship support to approximately 540 students in 1989 through programs administered by the Army Research Office (ARO), the Office of Naval Research (ONR), the Air Force Office of Scientific Research (AFOSR), and Defense Advanced Research Projects Agency (DARPA). These programs are advertised nationally through the distribution of brochures to schools and principal investigators on DOD contracts and grants, advertising in professional journals and announcements at professional society meetings. The fellowship programs are authorized as part of the annual appropriation for DOD research programs or, in the case of the National Defense Science and Engineering Graduate Fellowship program, directly in U.S. Code.

The AFOSR supports two of the oldest fellowship programs, Advanced Thermionic Research Initiative (ATRI) and Air Force Research in Aero Propulsion Technology (AFRAPT), both of which are targeted on critical Air Force needs and are conducted by a few cooperating schools. The ATRI Fellowship program was initiated in 1977 at Stanford, transferred to University of Utah in 1981, and to UCLA in 1987. It is focused on microwave and millimeter wave thermionic amplifiers and components and requires a B.Sc. in Electrical Engineering and U.S. citizenship. The AFRAPT program is a fellowship co-op program involving AFOSR, industry and university cooperation to provide a supply of critically needed engineers in the aeronautical propulsion field. The students are typically selected for the program in June, work at their respective companies over the summer, and begin graduate study in the fall. Thesis work may be done either at the university or at the supporting company. A stipend of $1,400 per month plus tuition and fees is paid during academic periods, and competitive salaries are paid during company work periods. Approximately half of the graduates are currently employed in the gas turbine industry. In 1989 the Joint Services Electronics Committee initiated another fellowship program targeting the electronics area. The program started at a level of $90,000 and is intended to increase to $300,000 in 1991.

The Laboratory Graduate Fellowship Program (LGFP) is an AFOSR program designed around the fellowship co-op concept. The program is primarily focused on the physical sciences and engineering, but includes some life sciences and behavioral sciences opportunities. Each fellow is assigned to an Air Force laboratory researcher in his or her area of interest to serve as mentor and advisor. Fellows, who are selected on merit, are encouraged to spend the summer period at their sponsoring laboratory. Fellows receive stipends plus tuition and fees. The university department attended by the fellow receives $2,000 per year to cover additional administrative costs. The program attracts high-potential students to science and engineering disciplines of interest to the Air Force. It supports approximately 75 students. A similar program, ONR Graduate Fellow program targets the physical sciences, engineering, biological science, oceanography, and cognitive and neural science. Students receive stipends plus tuition and fees. The students are encouraged to work in Navy laboratories during summer and vacation periods. Approximately 50 awards a year are made on the basis of merit as determined by an advisory panel of technical experts. In 1989, approximately 100 participants earned Ph.D.s, and the attrition rate for the program is less than 7%. Program history, exit surveys from fellows, and evaluations from the selection panels indicate the program is very successful in attracting and retaining high quality students and in integrating them into the research infrastructure. The Navy plans to continue the program at approximately the present level. A similar Science and Technology Fellowship program, administered by the Army Research Office, had 53 and 57 participants in 1987 and 1988, respectively, but is now being phased out in favor of two new fellowship programs (URI and NDSEG). The Army University Research Initiative program has a large fellowship component: in 1989 it had a budget of $3 million and supported 149 fellows. Administered by the Army Research Office, this program targets the physical sciences and engineering and is intended to increase the number of students pursuing careers in science and engineering. The program is expected to support about 130 fellows at a cost of $2.5 million per year.

The National Defense Science and Engineering Graduate Fellowship (NDSEG) program is the most recent fellowship program and has specific authorization in U.S. Code. Fellowships are awarded for study and research leading to doctoral degrees in mathematics, physical science, biological science, oceanography, and engineering. The program is sponsored by the three Services and DARPA and operated under contract. The Fellows receive stipends as well as full tuition and fees for three years. DOD also provides $2,000 per year support to the fellow's department at the university. Fellows are selected on the basis of merit by panels of experts convened by the contractor in each discipline. Approximately 4,200 applications were received for the first competition, and 126 fellows were selected with support as follows: ONR-39; ARO-31; AFOSR-30; and DARPA-26. The program is scheduled to receive $10.5 million in 1990 and $11 million in 1991, enough to provide three-year fellowships to approximately 120 fellows per year. The program has enjoyed exceptionally high quality applicants.

Programs to Perform Research

DOD is authorized to provide grants and contracts in areas of research relevant to its mission. In 1989 DOD spent approximately $800 million on basic and applied research contracts and grants to colleges and universities (exclusive of R&D centers operated by universities). A major benefit of this research is the training of graduate students in science and engineering. Approximately 9,000 full-time graduate students receive research assistantships and other related support. Assuming a cost of $19,000 per year for graduate assistantships, the level of support for assistantships would be approximately $170 million per year. Research programs of DOD are administered by the Army Research Office, the Office of Naval Research, the Air Force Office of Scientific Research, and the Defense Advanced Research Projects Agency and are coordinated by the Office of the Director for Defense Research and Engineering, Research and Laboratory Management. Individual assistant-ships are selected by the Principal Investigator and the school, and are not limited to U.S. citizens or nationals. The DOD research effort has been responsible for the training of a large number of the scientists and engineers who now work in the physical sciences and engineering and has therefore made a major contribution to the Nation's supply of highly trained scientists and engineers.

Programs to Provide Research Experience

Many of the programs that provide research experience at the undergraduate level are also conducted at the graduate level. In particular the Co-op programs and the Summer Hire programs are used extensively at the graduate level. The Air Force Graduate Student Research program provides for a ten-week research experience for graduate level science and engineering students. The program is closely coordinated with the Summer Faculty Research program so that faculty members can supervise the students' research.

Programs to Provide Science and Engineering Education for Employee Training

Training programs for employees include tuition support for a few courses, part-time work programs, and full-time, long-term programs.

Examples of the short-term tuition support programs include After Hours Tuition Support at Defense Intelligence Agency, the Tuition Assistance program of the Defense Mapping Agency, the NAVSEA Institute at Naval Sea Systems Headquarters (which offers career specific courses in cooperation with Virginia Tech), and Instructional Television offered by Naval Ocean Systems Center and Naval Research Laboratory. Under the On-Site Education Center Classes arrangement with the University of California at Chico State and Irvine, Service employees of the Naval Weapons Center receive live and televised graduate and undergraduate classes; a similar arrangement exists at the Army Corps of Engineers Waterways Experiment Station Graduate Institute, carried out in cooperation with Louisiana State, Texas A&M, and Mississippi State Universities.

Examples of part-time study programs include the Edison Memorial Training program at Naval Research Laboratory, which combines work and academic study at full salary after one year at NRL. The Graduate Academic program at Naval Ocean Systems Center is a 20 hour academic 20 hour work program at full salary.

Several programs allow participants to attend graduate school full-time while they receive full salary and tuition. Usually employees are eligible after three years of service and must commit to three years of continued service for each year of education. Programs of this type include the Mission Related Graduate program at the Army Corps of Engineers; the Long-Term Graduate Training programs at the Naval Sea Systems Headquarters and the Naval Ocean Systems Center; the Full-Time Graduate Education program at the Naval Air Development Center; the Full-Time Study program at the Defense Intelligence Agency; and the Advanced Graduate Research program at the Naval Research Laboratory. The Naval Research Laboratory's Select Graduate Student program offers one-half salary support for full-time study after only one year of government service. Several organizations offer long-term training opportunities in critical disciplines such as the Operations Research Systems Analyst Fellows offered by the Department of the Army Headquarters and Operations Research Advanced Fellow offered by the Army Materiel Command: the DCI Exceptional Analyst offered by the Defense Intelligence Agency: and the Coastal Engineering Education program. Water Resources Planning Associate and Water Resources and Environmental Law Associate, all offered by the Army Corps of Engineers.

The Air Force has two unique programs that couple recruiting with advanced education. The Palace Acquire program recruits recent college graduates in engineering into the Career Intern program and allows them to pursue advanced job-related studies leading to a M.Sc. degree during the trainee period. The program has been in operation since 1986 with about 50 interns per year, and has produced very satisfactory results. The Palace Knight program, developed and administered by the Air Force Civilian Personnel center, enables personnel to pursue advanced studies in their career fields at both the M.Sc. and Ph.D. level. New recruits are hired at the GS-7 level and report directly to their universities as their first duty stations. They usually receive a Master's degree during the first one to two years, then are assigned to a lab/work position for three years. With satisfactory ratings in their work assignments, the Palace Knight trainees can then return to school to continue their studies toward a Ph.D. degree. Full salary, tuition, and relocation expenses to the duty station are paid. A continued service agreement of three years for each year of training must be signed prior to employment. The program is slated to have approximately 100 participants per year.

Postdoctoral

Postdoctoral and faculty education programs expose new Ph.D.s to state-of-the-art science and technology or provide opportunities for faculty enrichment, including faculty at minority institutions. Since the programs employ trained scientists and engineers, they are classified as research programs. They also serve, however, to introduce faculty to areas of research interest to DOD and, in the case of the postdoctoral fellow programs, are one of the most effective recruiting programs available to the laboratories.

Programs That Perform Research

The National Research Council Research Associateship program is one of the oldest education programs supported by DOD, dating back to 1957. During 1989 the program placed 239 postdoctoral fellows in 17 DOD laboratories and centers, including all three Services and several agencies. The program is operated for the Department of Defense by the National Research Council. Most associateships are limited to U.S. citizens, but the Air Force accepts foreign nationals. The NRC postdoctoral program is highly regarded and has provided many outstanding scientists and engineers for the DOD laboratories and centers.

The Office of Naval Technology supports the ONT Post-Doctoral Fellowship program for selected science and engineering fields of interest to the Navy. In 1989 the program placed 77 participants at participating Navy laboratories.

Programs Targeted to Increase the Participation of Women and Minorities

The Women Science Scholars program, developed by Office of Naval Research, provides postdoctoral experience for women with Ph.D.'s are at points in their careers where this experience can make a critical difference. The program is based at Bunting Institute of Radcliffe College and is operated in collaboration with other New England schools. The women are paid a stipend of $25,000 for one year. The program is rated highly by the participants and credited with substantially aiding their careers and attracting them to research areas of interest to DOD.

NEW INITIATIVES

The National Defense Science and Engineering Graduate (NDSEG) Fellowship program is the most recent graduate research education initiative. The program was authorized by Congress in 1989 to increase the number of students pursuing advanced degrees in science and engineering fields of importance to DOD. The fellowship pays a stipend for three years as well as full tuition and fees for a period of three years. The program will provide fellowships for approximately 120 fellows a year with a total of 360 in the program after three years. Support for the program is provided by the Service research offices (ARO, ONR, AFOSR) and DARPA. The initial solicitation for fellows was very well received with 4,200 applications for the 126 NDSEG Fellows selected in 1989. Annual funding for the program was $10 million in 1989. In report language, the Congress has called for $20 million for 1991.

SUMMARY

Among the most effective recruiting programs are the Career Intern programs that recruit from campus for an accelerated promotion track and also provide advanced education. Co-op programs are also rated as very effective, with recruitment rates of 65-70% reported in some organizations. At the advanced degree level, the postdoctoral research associateships are very effective in providing a continuing supply of well qualified graduate scientists and engineers for conducting research in DOD laboratories or under university grants and contracts.

The in-house training programs are generally considered important both for providing educational opportunities for employees and as a recruiting tool.

Among the research office programs, the research assistantships resulting from research awards to universities are considered the most effective because the student support is coupled with research performed in an area of interest to DOD. Fellowship programs with a laboratory tie are next most effective in terms of training students in an area of research of interest to DOD and recruiting the students upon completion of their education. In terms of direct recruitment of scientists and engineers, the unrestricted fellowships appear to provide the least return to DOD in terms of direct recruitment of scientists and engineers.

DOD's investment in science and engineering research and related education programs at HBCUs rose to approximately $30 million in FY 1989. Moreover, efforts are being made to meet the requirements of section 1207 of Public Law 99-661, the 1987 National Defense Authorization

Act, which directed DOD to reach a goal of 5% for contract awards to small disadvantaged businesses, HBCUs and MIs. Until recently, DOD's relationships with a large number of these institutions was circumscribed, because DOD's support for science and engineering education at the university level was derived from authority to conduct research, and because fewer than a third of the 106 HBCUs have graduate programs in science and engineering fields, and only ten offer the Ph.D. degree. Recently passed legislation provides authority that will enable broader DOD activity in educational programs at HBCUs and MIs.

Precollege programs range from short exposure tours, seminars and science fairs to more intense tutoring and summer experience programs. The most effective are those that influence career decisions for science and engineering, provide the necessary career guidance and provide a glimpse of the excitement and adventure in a science and engineering career. The High School Apprenticeship Programs provide these elements.

DOD brings large numbers of high school, undergraduate and graduate students, postdoctoral scholars and faculty researchers into its laboratories for research experiences during the summer.

The DOD has substantial experience and resources invested in the training and preparation of personnel. The increasing sophistication and complexity of the defense systems in use today require the Department to train the technicians and managers necessary to maintain and utilize these systems effectively. The development of new systems depends on the science and technology base in the DOD laboratories and the defense industry, and this in turn depends on new knowledge generated by the university, industry and DOD laboratory research communities.

The DOD has the experience and capabilities to contribute to the improvement of the quality of science and engineering education and to motivate and educate a new generation of scientists and engineers. The DOD uses its authority to recruit, develop and retain scientists and engineers and also to motivate students to pursue careers in science and engineering.

Senator **Bingaman**. Thank you very much. I will start with a few questions. Last year's defense bill required that DOD submit a plan which outlined the process by which DOD would upgrade manufacturing. A few weeks ago, Mr. McMillan testified before this subcommittee that DOD was currently working on this plan and that we could expect to receive it by the end of the fiscal year, or the first of October. That was a longer time frame than I had had in mind when we discussed that change in the law. We had thought we would receive the plan in time to act upon it within the year. Are we going to have your management plan for education before we mark up a bill this year so that we can review it?

Dr. **Kimmel**. I suspect the management plan will be available and be coordinated and forwarded to OSTP within the next 120 days or so. The plan is going to address the management——

Senator **Bingaman**. So 120 days is 4 months, which means not before the first of September. Is that what you are saying?

Dr. **Kimmel**. About that time frame, sir. The management plan is going to focus on the management actions. It is not going to necessarily focus on the resources or the programmatic aspects of science and engineering education.

Senator **Bingaman**. Will it focus on how you are managing what you have in place?

Dr. **Kimmel**. It is going to put in place an infrastructure to collect the data, review the data, and to evaluate the measures of effectiveness of what we are doing, and to put in place a series of actions so we can formalize the participation of the services and defense agencies.

Senator **Bingaman**. Recalling from last year's hearing, am I correct that the Department of Defense spends more in support of math, science, and engineering education than any other Federal agency?

Dr. **Kimmel**. I believe that is true.

Senator **Bingaman**. Has there ever been a plan or an overview document prioritizing the allocation of those dollars?

Dr. **Kimmel**. The program has been built over a historical period, and the emphasis has been placed upon the services to recognize their individual requirements and devise programs that would satisfy their priorities. The management plan that I am addressing will seek to take the best of each of the service proposals and to unify and to integrate so we can get some leveraging of results.

Senator **Bingaman**. I was at the White House a few weeks ago when the President made his statement about initiatives in education, which you refer to in your statement. He talked about how we needed to become a nation of students, and that he was going to start taking instruction in how to use a computer. He also stressed the need to have education communities around the country.

With regard to DOD's school system, I think you indicated in your opening statement that there are at least 200,000 students in your own schools. You also commented that the dependent school sets specific targets for improving science, math scores, and standardized achievement tests. Is there a plan in place for what is going to be done to reach those targets that you could make available to the committee? There was not last year, and I would like to know if there has been some plan of action prepared as to how you are going to upgrade math and science education in those schools.

Dr. **Kimmel**. As you know, Mr. Chairman, the DOD is very proud of the fact that they have traditionally had higher scores than the national average. We do have a strategy on how we want to continue to look at, reexamine, and if need be restructure our math and science program in the DOD. That is continually under review. And if the strategy is desired we can make it available to you.

Senator **Bingaman**. But it is a strategy for what is to be done to get from here to first in the world by the year 2000?

Dr. **Kimmel**. Yes, sir.

Senator **Bingaman**. I would like very much to get a copy of that. I think that would be very useful. In connection with this effort that the President has initiated urging everybody to pursue continuing education and to have education communities, we included language in last year's bill, which I think you referred to, urging that the various Defense Department laboratories initiate partnerships with educational institutions and try through their personnel and resources to upgrade science and math instruction in the locations where those partnerships were possible. Can you report progress in that area, or is that awaiting the completion of a plan?

[The information follows:]

THE NATIONAL EDUCATION GOALS

Department of Defense

Education

OVERSEAS DEPENDENTS SCHOOLS

STATESIDE DEPENDENTS SCHOOLS

CONTINUING, ADULT, AND POSTSECONDARY EDUCATION

Implementation Targets

A Message from the Director: Not long ago, on the historic campus of the University of Virginia in Charlottesville, President Bush and the Nation's Governors met and rededicated themselves to excellence in education for all Americans. A call was made to establish national education goals that focused on results, accountability, and flexibility in the use of Federal education resources.

On January 31, 1990, in an address before a joint session of the Congress on the State of the Union, President Bush unveiled the national performance goals for education. These goals do not represent an attempt to mandate a national curriculum or to force specific reforms on States and local districts. They provide, for the first time, a sense of direction for individual and collective efforts to improve the quality of education for all Americans.

Our future depends on how much and how well we invest in our children—from preschool through adult literacy. Nothing else that we do and no other investments we make will be as important. Education is the key to our future. We have set ambitious educational goals and will spare no effort in pursuit of these goals. I am confident that with hard work, dedication and cooperation on the part of parents, students, teachers, administrators, and military and community leaders, we will achieve them. These goals are not wishes we can hope for, they are targets we must achieve.

INTRODUCTION

At the National Education Summit, Governors from across the Nation met to discuss the status of American education and the methods by which our education system could be strengthened. At this meeting, all 50 Governors and President Bush affirmed the importance of education to the economic, political and social success of the Nation. As a result of this emphasis on education as essential to the strength of the country, the Governors and President Bush agreed upon six national goals for education. The national goals contained here are the first step in carrying out the commitment of developing an educated citizenry suitable for global competition and the 21st century. For each of these goals the Department of Defense (DOD) has developed implementation targets to achieve these ideals in DOD schools.

Education is central to our quality of life. It is the heart of our economic strength and security, our creativity in the arts and letters, our discovery in the sciences, and the perpetuation of our cultural values. Our schools must cultivate an educational performance that is second to none. All Americans, not just a few, must be able to make knowledgeable decisions, to adapt to changing environments, and to understand the world around them. They must understand and accept the responsibilities and obligations of citizenship. They must continually learn and develop new skills throughout their lives.

We must become a nation that values education and learning. We must recognize that every child can learn, regardless of background or disability. We must recognize that education is a lifelong endeavor not just a temporary undertaking for our children. Sweeping fundamental changes in our education system must be made. Educators must be given greater flexibility to devise challenging and inspiring strategies to serve the needs of a diverse body of students. Achieving these changes depends, in large part, on the commitment of professional educators. Their daily work must be dedicated to creating a new educational order in which success for all students is the first priority, and they must be held accountable for the results.

This is not the responsibility of educators alone, however. Parents must be more interested and involved in their children's education, and students must accept the challenge of higher expectations for achievement and greater responsibility for their future. In addition, military communities and civic groups have a vital role to play in ensuring educational success. Attaining the goals will require the development of new and better ways to use financial and human resources that are devoted to education. Restructuring the system will not be easy.

If the United States is to maintain a strong and responsible democracy and a prosperous and growing economy into the next century, all of our citizens must be involved in achieving these goals. Every citizen will benefit as a result. When challenged, the American people have always shown their determination to succeed. The challenge before us calls on each American to help ensure our Nation's future.

NATIONAL GOALS FOR EDUCATION
DEPARTMENT OF DEFENSE
OVERSEAS AND STATESIDE DEPENDENTS SCHOOLS
IMPLEMENTATION TARGETS
(Revision of April 23,1991)

GOAL 1: By the year 2000, all children in America will start school ready to learn.

1.1

· The Department of Defense Overseas and Stateside Dependents Schools will increase the number of regular education programs for preschool children. In the overseas schools, the number of sites will be increased from 6 to 29 and the stateside schools will implement the program in the 18 sites by school year 1994-95 in order to help prepare children for school.

1.2

· Beginning in school year 1992-93, the Department of Defense will implement a parental participation program in all child development programs to encourage parental involvement in child development activities. As a part of this program, the Overseas Dependents Schools will provide parent education guides to all parents who have children in overseas child development centers, pre-kindergarten programs, and Overseas Dependents Schools preschool programs for handicapped children. The Department of Defense will also continue to encourage more active parent/teacher/student advisory panels.

1.3

· The Overseas Dependent Schools will monitor national efforts to assess the achievement of this goal and will participate in such efforts when they become available.

GOAL 2: By the year 2000, the high school graduation rate will increase to at least 90 percent.

2.1

· The Overseas Dependent Schools and Stateside Dependents Schools will achieve a documented high school graduation rate of at least 90 percent by the year 1995.

GOAL 3: By the year 2000, American students will leave grades four, eight, and twelve having demonstrated competency in challenging subject matter, including English, mathematics, science, history, and geography; and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.

3.1

· By the year 2000, the percent of Overseas and Stateside Dependents Schools students scoring below the 1990 national 25th percentile on a standardized achievement test will be reduced by 20 percent.

· By the year 2000, the percent of Overseas and Stateside Dependents Schools students scoring between the 51st and 75th percentiles on a standardized achievement test will be increased by 10 percent.

· By the year 2000, the percent of Overseas and Stateside Dependents Schools students scoring above the 1990 national 76th percentile on a standardized achievement test will be increased by 10 percent.

3.2

By the year 2000, all high schools in the Overseas and Stateside Dependents Schools will offer at least two Advanced Placement courses.

3.3

· By the year 2000, the percent of scores 3 or above earned by graduates of the Overseas and Stateside Dependents Schools on the Advanced Placement Examinations will exceed the national percentage by five percent.

3.4

· By the year 2000, the Overseas and Stateside Dependents Schools will double the 1990 percentage of high school graduates having completed the third year of a foreign language and the percentage having completed the fourth year of foreign language.

3.5

· DoDDS will develop a systemwide writing assessment program and by the year 2000, at least 90 percent of DoDDS students assessed will meet the criteria for proficiency.

3.6

· By the school year 1993-94, DoDDS will offer full year foreign language courses in both 7th and 8th grades preferably in the language of the foreign nation in which the students live.

3.7

· By the year 2000, the percentage of students taking the SAT from each minority group will equal or exceed the percentage of all students taking the SAT in the Overseas and Stateside Dependents Schools.

3.8

· The Overseas and Stateside Dependents Schools will work closely with the Center for the Study of Evaluation at the University of California at Los Angeles and other major universities in the development of performance-based assessment procedures which expand the assessment of student performance and contribute to improving instruction.

GOAL 4: By the year 2000, U.S. students will be first in the world in science and mathematics achievement.

4.1

· The Overseas and Stateside Dependents Schools will increase enrollment in advanced mathematics and science (e.g., algebra II, math analysis, calculus, chemistry, physics and biology II) each year over the enrollment in school year 1989-90 with the objectives of increasing by 15 percent the percentage of graduates completing algebra II and chemistry; increasing by 25 percent the percentage of graduates completing math analysis; increasing by 30 percent the percentage of graduates completing physics; and increasing by 100 percent the percentage of graduates completing calculus and biology II.

4.2

· By the year 2000, the percent of students in the Overseas and Stateside Dependents Schools scoring below the 1990 national 25th percentile on the math and science sections of a standardized achievement test will be reduced by 20 percent.

· By the year 2000, the percent of students in the Overseas and Stateside Dependents Schools scoring above the 1990 national median on the math and science sections of a standardized achievement test will be increased by 10 percent.

· By the year 2000, the percent of students in the Overseas and Stateside Dependents Schools scoring above the 1990 national 75th percentile on the math and science sections of a standardized achievement test will be increased by 10 percent.

4.3

· DoDDS will provide introductory training for 2,500 teachers and 400 administrators, and intensive training for 400 teachers and 50 administrators by 1995 in curriculum standards, evaluation standards, and professional standards for teaching mathematics (K-12) as proposed by the National Council of Teachers of Mathematics.

GOAL 5: By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

5.1

The intent of the above item is met fully by the goals under 3.1 and 4.2 above.

5.2

· By the year 2000, the Overseas and Stateside Dependents Schools will seek to increase, by 20 percent, the percentage of graduates who are qualified to enter college.

5.3

· Beginning with school year 1991-92, the Overseas and Stateside Dependents Schools will begin accepting applications from teachers who have been certified through a state-approved alternative certification program. This will provide former military personnel with career opportunities and take advantage of the highly specialized technical skills possessed by individuals leaving the military service.

5.4

. The Department of Defense is assisting the Office of Personnel Management in developing and field testing an Adult Literacy Test to be used in the Federal workforce to permit comparison of government employees with a national sample of adults.

GOAL 6: By the year 2000, every school in America will be free of drugs and violence and will offer a disciplined environment conducive to learning.

6.1

· By 1995, the Overseas Dependents Schools will have established the Drug Abuse Resistance Education (DARE) program in every middle school to complement current programs offered in the elementary schools.

6.2

· Beginning in school year 1991-92, the Overseas and Stateside Dependents Schools will closely monitor school disciplinary actions and increasingly cooperate with local family support centers to provide intensive support for flagrant offenders.

A CHALLENGE

These national educational goals are not the President's goals or the Governor's goals; they are the Nation's goals. Achieving them will require fundamental changes in the way we educate our citizens, in our attitudes toward teaching and learning, and in our very culture. This cannot be accomplished by our educational system as it is presently designed. Substantial, even radical changes will have to be made. A concerted effort on the part of every citizen is necessary. The President and the Governors challenge every family, school, school district and community to adopt these national goals as their own. Our education systems must be able to develop citizens who are informed, literate and productive. The Overseas Dependents Schools, the Stateside Dependents Schools and the Continuing, Adult, and Post-Secondary Education Programs in the Department of Defense must ensure that future citizens are able to resolve problems, to make wise decisions, and to continue their education throughout their lives. These educational goals are the beginning, not the end, of the process.

Dr. **KIMMEL**. I think it is too early to tell if there is real progress. There is significant activity that has been documented in piecemeal reports to this subcommittee, and has been reported to the FCCSET as part of the report that you mentioned earlier. Clearly the Navy has some arrangements, has a formal set of relationships with nearly 800 high schools and elementary schools across the country. The Army has an extensive program at the junior and high school levels working through the Science Fair programs. But as a result of the 1991 authorization act, I think I would be misdirecting the committee to say there has been significant progress since the passage of that act.

Senator **BINGAMAN**. Is there anything being done at the elementary level? The information I have received from several different experts on the subject is that students essentially decide whether to pursue math, science, or engineering by about the seventh grade, and if you have not decided to do it by then, you do not do it. Is there any effort being made by DOD to reach out to support schools in the elementary grades?

Dr. KIMMEL. As a matter of fact, DOD is a sponsor of an effort by the National Academy of Sciences and Smithsonian Institution that is sponsoring a national science research center whose purpose is to develop materials, aids, and resources to assist the elementary teachers, as well as the science coordinators in the school systems so as to better give them, if you will, modules of instructions to help them prepare for their classroom activities.

Senator BINGAMAN. Did you say that is a program through the Army?

Dr. KIMMEL. The Office of the Secretary of Defense is the granting authority.

Senator BINGAMAN. So it is a grant that was made to the Smithsonian?

Dr. KIMMEL. The Smithsonian and the National Academy of Sciences for the establishment of a national science resource center.

Senator BINGAMAN. Senator Coats, do you have any questions?

Senator COATS. Dr. Kimmel, one of the issues that the committee has discussed and grappled with a little bit over the last few years is the whole issue of the benefit that comes back to DOD for its substantial investment in these various programs that you describe. And we have bounced back and forth the idea of the direct benefit versus the indirect benefit, and all of that leading up to whether or not there ought to be some stipulation or some requirement of some specific pay back. I mean, we are making a substantial investment here in a number of people, and the question is is it reasonable or practical or feasible to require some kind of a return for our investment? I wonder if you would just comment on that in general and give us thoughts of the Department of Defense on that subject.

Dr. KIMMEL. I think it is a combination of an answer. The first is part of what we recognized when we initialized the management planning effort. We need to get a better handle on how to measure the effectiveness of what we are doing. It is not sufficient just to support what we are doing by saying that it is there. But the question I think at the root of your question is how well are we doing, and is it providing the results that we all seek to acquire. And so by focusing on measures of effectiveness, at least trying to plant the seed of how to measure the effectiveness of all these programs and put them into some sort of cohesive fashion, you come up with a series of ideas that are yet untested.

For example, as you recognized, we find that for many of the students, the 6th through 10th grade is about the turn off point. Somewhere in that time frame they decide that the science or mathematics career is not in their interest. And so one idea of how to measure the effectiveness of all these efforts might be, as we target the elementary schools and the junior highs, what is the rate of return of students that return to a science or mathematics course after the first required course, and is that a positive trend.

Others might be the measures in the SAT, which is administered nationally and is a standard basis. Another measure might be the participation level as well as the quality of participation in the very science fair that is already in place. And certainly as you look at the number and type of applicants and the quality of the applicants for the fellowships and assistantships and other available programs to the students, you can get a measure of success. And ultimately, of course, it is how well we maintain our competitiveness in the technology areas both in the civilian and defense sectors.

Senator COATS. Those would all, I would think, fall under the classification of indirect benefits. I mean, you have a climate, you have a community of individuals with the kind of technical expertise that might enure to the benefit of the Department of Defense in some way, but the other question—and I think that is important to measure that. But the other question is whether or not we should put some stipulations, at least on some of the programs, requiring a direct pay back, a direct benefit. In other words, we pay for the education of those who attend the military academies, but we require a certain number of years of service.

Is it feasible or would it be a negative to the program to tie some direct benefit requirement, some direct pay back into these programs? If we are going to finance, for instance, the graduate education of a particular student in science or engineering, do we want to tie that to a commitment for a certain period of time to either the Department of Defense or a related agency, or defense connected research lab, or whatever?

Dr. KIMMEL. First, the history of supporting science and engineering education dates back into the late 1970s. Through the decade of the 1980s our primary focus was the graduate education level where we found the need to try to encourage U.S. students to remain as graduate teaching assistants or to remain in the area for their own professional careers. Now in the 1990s we are starting to focus more in the elementary schools. It is going to be hard pressed to put some sort of direct pay back for the elementary school and the secondary education areas.

The pay off by supporting graduates and the pursuit of the undergraduate levels ultimately will appear in either the defense industry or in the government sector. In either case I think the country benefits. But to put a direct linkage I think would handcuff the overall aims and objectives of the programs.

Senator COATS. Is there any program that currently is funded through the Department of Defense that you would think would be liable to tie some direct repay back? Any advanced program or commitment? I am not familiar with all the programs that we have.

Dr. KIMMEL. I am not aware of any, and I would not—there are some programs now that have a requirement, like the Palace Knight program. But aside from that I do not believe there are any programs now that ought to have more direct pay back periods stipulated.

Senator COATS. Thank you. Thank you, Mr. Chairman.

Senator BINGAMAN. Before we go to the second panel, I would like to ask a little more about this partnership issue. You returned answers to some of the prehearing questions that we submitted to you regarding these partnership agreements that do exist. It was very clear the Army has a variety of partnerships with various institutions. The Navy seemed to only have associations with high schools, at least in the list that you gave us. I am not sure where the Air Force stands on the issue. Do you have any more information, or will this be contained in your report? Can you explain that difference? Is it the result of policy decisions?

Dr. KIMMEL. Quite the contrary. In the limited amount of time that we had to prepare the response to the questions we gathered what lists were immediately available. The Army has a very formal program executed by the Army Research Office in Research Triangle Park that works and has these formal arrangements with the universities associated with that list. The Navy has a very formal program under Adopt-a-School that is articulated in that list.

But there are numerous informal programs in all three services that cut across the secondary, elementary, as well as the university levels, which are not on that list that was transmitted to you. Given time we could expand upon that list, but I think the list exemplifies the types of activities now in place in the program, but still needing to be formalized and melded in some sort of cohesive fashion. The management plan seeks to do some of that.

Senator BINGAMAN. You said that your management plan does not have programmatic content. Specifically, the DOD plan will not set priorities such as concentrating graduate and undergraduate funds in manufacturing engineering or in some other particular area. Am I right that you are not going to have that kind of information in the management plan?

Dr. KIMMEL. I think the first role of the management plan is to put a mark in the sand of where we are, and then to leverage those activities and couple them with other initiatives, such as the manufacturing technology initiative, high performance computing initiative, and many other things that are important to the Department to influence and to get some leveraging of the investments.

Senator BINGAMAN. Do we need to initiate some additional analysis on the part of DOD to set its priorities, not just what its priorities have historically been, but its priorities through the rest of this decade? That kind of information would be useful to us. We can pass statutes in Congress stating what we think your priorities should be, but we need your input on that. Also, do we need to essentially request another report from DOD or some response from you as to what area you think DOD can do the most good? I think you indicated yourself that you do not have a good sense of which programs are really beneficial and which are not.

Dr. KIMMEL. What I think I said was we need to make sure that we have the right measure of effectiveness in place so we can evaluate the utilities of the program. We are certainly receiving more than enough applicants. Many of our programs, our fellowship programs are oversubscribed. There is, by the list that we previously discussed, ample opportunity to get in and have volunteers to work with local universities and to loan equipment and to help to teach and to be judges at fairs, and one thing or another.

But you need to tailor the program for the locality, and we have not yet addressed that. And that is what the management plan seeks to do by putting together at least a forum where we can have service and defense agency discussions on pointed areas we need to address and adjust the program accordingly. And so I am not volunteering for another report. I think you need to let the plan run and see what it looks like, and then let us have an opportunity to execute the actions forthcoming from the plan.

Senator **Bingaman**. Okay. But do you think the plan will actually have some clear direction as to what DOD intends to try to accomplish in this field of science, engineering, and math education over the next 5 years?

Dr. **Kimmel**. Yes, sir, I think it will lay the framework to put forth a cohesive program to make that achievable within the statutory limits and the goals that we have established. I think we can make it happen.

Senator **Bingaman**. All right. Senator Coats, do you have other questions?

Senator **Coats**. I have no additional questions.

Senator **Bingaman**. Senator Nunn.

Chairman **Nunn**. No.

Senator **Bingaman**. We will look forward to hearing more from you as your plan develops. Why do we not go ahead to the second panel and ask Professors Thomas, Bowen, and Yang to please come forward.

Dr. **Kimmel**. Thank you.

Senator **Bingaman**. Thank you. Dean Thomas, why do you not begin, and we will then go to Professor Bowen and Dean Yang.

STATEMENT OF MICHAEL E. THOMAS, EXECUTIVE VICE PRESIDENT, GEORGIA INSTITUTE OF TECHNOLOGY

Dr. **Thomas**. Thank you, Mr. Chairman. Let me just summarize the remarks which have already been entered into the record that I would like to make. Manufacturing engineering requires a multidisciplinary approach. It varies according to the areas of emphasis. Several common components that are important in manufacturing engineering are materials, and then the processing of those materials, the controls, the material handling, the scheduling, quality issues, in addition to the order processing, packaging, and distribution.

And let me just say that distribution is one of the major cost components of modern manufacturing and an area of important strategic advantage in the United States because of our relative closeness to the customer as opposed to off-shore manufacturers. Each of these components has a different undergraduate disciplinary base, and hence no single undergraduate program, in my opinion, can provide the kind of breadth needed and the depth needed to address complex manufacturing issues that we face in this country today.

Let me also point out that multi-disciplinary activity is countercultural in academic environments. We tend to look very deep and very narrow, and the kinds of engineers that are needed in manufacturing are engineers who have substantial technical skills, but also have those across a broad range. And so incentives are needed to overcome the cultural biases against such multi-disciplinary work that tend to exist in universities.

For example, the computer integrated manufacturing systems program which was started at Georgia Tech in 1983 resulted from a $4 million grant from IBM, plus continuing support from a number of industrial firms. Four million dollars is enough to get the attention of university faculty, and a number of them participated very actively in developing this program. It involves faculty from a variety of disciplines, mechanical engineering, electrical engineering, industrial engineering, computing, management, and they are involved in a variety of different ways. Special new graduate courses were developed and taught, and several of those are being team taught by members of this group that have their base in one of the disciplines that I mentioned earlier. To this point 337 have graduated from this program, and there are another 150 enrolled. This is a graduate level program.

Even with the active involvement from industry we are not able to provide enough hands on experience or up-to-date equipment to students in this program, especially in the electronics manufacturing field. The cost of keeping up-to-date in manufacturing is exorbitant.

Senator BINGAMAN. This was in appliance manufacturing, you said?

Dr. THOMAS. No, in electronics manufacturing.

Senator BINGAMAN. Electronics manufacturing.

Dr. THOMAS. Yes. New approaches are needed, I think, to address these problems. M.I.T.'s Leaders for Manufacturing is one such approach. They get the students to industrial settings, which helps overcome the dearth of manufacturing types of equipment in universities, but it is a very expensive program. Professor Bowen can relate to you how much industrial support they have needed in order [illegible] generate this program.

Another approach would be learning factories, which would be analogues to teaching hospitals. There are some examples of this that already exist. The Defense Logistics Agency supports a research program in precision gear manufacturing that also has an impact on the teaching programs at the institution where it exists. DLA also has demonstration facilities in uniform manufacturing that is run jointly by Georgia Tech and Southern Tech in Atlanta. The Army's MICOM program has a proposed center for Army sensor technology which would be housed at Georgia Tech's new manufacturing research center and would have significant input from the micro electronics research center also at Georgia Tech. The Great Lakes Consortium on composites manufacturing, which intends to have a learning factory associated with that program, is also being funded by the Defense Department through the Navy.

These all have the advantages of providing state of the art research activities combined with teaching efforts, and that sort of program has made a great impact through the engineering research center, for example at Purdue and their intelligent manufacturing systems program.

The facilities and equipment problems in universities are well documented. You go to visit any university laboratory today and you will find that the equipment in university laboratories that is used, especially in the teaching programs, is old technology. It is hand me downs from industry. There has been no significant Federal effort to address the facilities issues for education, or the equipment issues for education to date in the past 20 years, with a few exceptions where isolated programs have been targeted at specific universities.

However, there are some States that are helping. Much more is needed to be done. One example is the Georgia Tech Manufacturing Research Center. It is a 120,000 square foot building. It is a new facility. It has high bay capability as well as load-bearing floors. It is modular and very flexible, and it was built for us by the State. The State provided $15 million for that, and we will open that facility this summer. Four companies have provided $1 million each to support research activities in this facility that have been targeted toward electronics manufacturing. Those four companies are IBM, Digital Equipment, Ford, and Motorola.

It will provide space for up-to-date manufacturing research and for the engineers from these companies to work alongside the faculty and graduate students in pursuit of common research interests. Major companies can participate in this, however, small and medium sized companies have difficulty in coming up with enough funds for them to participate. And so we need to find ways to transfer new technology rapidly to the small and medium sized companies.

Another important issue is the fact that most of the Federal Government research activities that have been directed toward universities have been directed primarily to basic research activities. There is the 6.2 and 6.3 money in the DOD budget that is devoted toward proof of feasibility or proof of concept, but that typically has not been spent at universities. We need to think about directing some of that money toward universities to help them in their mission of doing research which leads to products that are going to be useful, and also to help influence the kind of educational programs that are provided in the universities. This will allow what Dr. Bromley referred to as the need to translate what research labs are doing into something useful in the private sector.

Two other issues that I would like to call to your attention are the problems associated with life-long learning. The technology that we teach in engineering schools is rapidly out dated. Things are changing very rapidly, and that emphasizes the need for opportunities for more extensive life-long learning opportunities for our scientists and engineers in this country's work force.

A second major initiative which I think would be useful is one that we have started at Georgia Tech recently. It is a graduate co-op program. We are all aware of undergraduate co-op programs which have students go work in industry and alternate periods in industry with periods at the universities. We are doing that now at the graduate co-op level, and even involving doctoral level work. And this provides our students with what we are unable to provide them in the universities, and that is access to the first rate research equipment that is necessary both in manufacturing and basic research. The universities simply do not have the resources to provide that sort of thing across the board, so graduate co-op programs are important. And there is one agency of the Federal Government, the Department of Education, that has been mildly supportive of such efforts in the past.

In summary I think a major new initiative is needed at the Federal level to address the manufacturing education issues in this country. The impact of technology was certainly well apparent in the recent conflict in the Middle East, but in order for us to remain competitive not only militarily but economically in this country we have got to do something to regain our competitive edge with our economic activities, or our standard of living will suffer significantly from that.

That concludes my comments.

[The prepared statement of Dr. Thomas follows:]

PREPARED STATEMENT BY DEAN MICHAEL E. THOMAS, DEAN OF ENGINEERING, GEORGIA INSTITUTE OF TECHNOLOGY

MANUFACTURING ENGINEERING EDUCATION SUPPORT FOR MULTIDISCIPLINARY ENGINEERING PROGRAMS

Preparing a student for a career in manufacturing is a multidisciplinary task that requires innovative changes not only within the academic institutions but also in the relationships with industry in general. True partnerships must be forged with industry. The administration of technological courses of study will require a reexamination of deep-rooted cultural tenets that have withstood the test of time.

Traditionally, engineering education has successfully relied on courses of study based on monodisciplinary programs to prepare engineers for careers in specific fields of practice such as electrical engineering, civil engineering or industrial engineering. However, today when an engineer enters a large manufacturing enterprise he is expected to be a member of a team whose members have a wide range of intellectual competence. If the company he has joined is small, he finds that he will be expected to marshal resources and work with external consultants and professional engineers representing a broad cross section of engineering disciplines. The requirements for producing new complex products and designing modern processes mandate this level of involvement of many practitioners. No single disciplinary background in itself is adequate.

In retrospect this comes as no surprise. Yet academic institutions have tended to rely on tried and true departmentalized organizational structures in their educational programs. This departmentalization by discipline does not reflect the real world of practice although it is ideally suited for educational purposes. There is a need to reexamine both the administrative structure and the cultural changes that will be required to allow a higher degree of flexibility in the ability of academic institutions to respond to the needs of a rapidly changing technological environment.

The Computer Integrated Manufacturing Systems Program at Georgia Tech exemplifies the type of educational program that is relevant and responsive to industrial needs. Beginning in 1982, over 40 faculty representing seven schools within the College of Engineering at Georgia Tech, the College of Management and the College of Computing teamed to develop a graduate-level program that would better prepare an engineer for a career in manufacturing. Within the first 3 years 21 new courses were developed and a number of other courses were modified—tailored—to permit students from one discipline to successfully attempt technical courses in other disciplines. Fourteen companies assigned representatives as advisors in developing the curriculum and the research program and also committed funds to defray the operating costs generated by a program of this magnitude. Three hundred and thirty seven students have graduated from this program since 1983. In a recent sample of 50 graduates, all but two were employed in manufacturing or direct support of manufacturing. This year 150 students are enrolled.

For such an effort to be meaningful and meet the demands of industry, we had to go much further than compiling a list of existing courses into a "new" program in manufacturing engineering. Few institutions have the resources and the industry interfaces to accomplish the same level of intensive effort. This program would not have been possible without the involvement, participations and commitment of key executives from industry. It would not have been possible without an administrative environment that was demonstrably supportive to facilitate the cross-disciplinary aspects of such an effort.

There is a need for "seed" money to prime the educational pump necessary to develop programs of this kind. The opportunity for matching funds from industry would be greatly enhanced if there was access to State and Federal support.

SUPPORT FOR A LEARNING FACTORY

The capability of academic institutions to prepare students for a career in manufacturing leaves much to be desired. Corporate America spends billions annually in training scientists and engineers. This orientation takes place as soon as they are employed and continues for the rest of their careers. In truth, much of this training tends to be company or industry specific and outside the province of institutions of higher learning. This industrial training is an expense that is added to the cost of manufactured goods. There is good reason to challenge this method of maintaining the level of technical competence necessary to survive in a highly competitive global environment.

There is a need for access to a full scale "learning factory," preferably on campus, for effective industry/university collaboration. A university on its own cannot create a credible manufacturing environment. The very act of carrying research to a feasibility or demonstration stage will require a partnership structure to move an idea from the laboratory to the shop floor and from there to the marketplace—a multiplicity of tasks foreign to the academic environment. A "micro-factory" or "learning factory" could be the test bed—the necessary structure to insure some relevancy with the "real" environment of competition in a quality-conscious world. The partners in this effort would have to be from industry in order to get the input, experience, and expertise necessary for this task.

The notion for a "micro-factory" is not new. The Defense Logistics Agency is currently funding an "instrumented factory" for research in manufacturing aircraft quality gears at the Illinois Institute of Technology. The same agency has funded a demonstration facility at Southern Tech for the manufacture of military clothing under the direction of Georgia Tech. The Army Missile Command has initiated steps to pursue a collaboratively managed "Manufacturing Center for Army Seeker Technology" utilizing resources at the Microelectronics Research Center and the Manufacturing Research Center on the campus of Georgia Tech along with the facilities located in MICOM's Manufacturing Technology Division in Huntsville, Alabama. The Great Lakes Composite Consortium in Kenosha, Wisconsin, funded by the U.S. Navy, contains in its plans a "teaching factory" for the rapid transfer of new technologies to engineers, technicians, operators and managers in manufacturing facilities.

This is by no means a definitive listing but illustrative of the increasing yet uncoordinated efforts to organize the resources existing within the government, industry and academic research laboratories that could stimulate and accelerate the transfer of new discoveries into the private sector. These micro-factories will proliferate to fulfill the unsatisfied demand for a more effective process . . . "to translate what the research labs are doing into something useful in the private sector" (to paraphrase Dr. Allan Bromley's remarks at the 4th Annual Meeting of the Council on Competitiveness).[1]

There is strength in this diversity of efforts to facilitate technology transfer. But there is also an opportunity to capture and share the emerging organizational and administrative developments to minimize the inevitable duplicative and redundant efforts that would thereby sub-optimize the Nation's resources. No single institution or organization could reasonably have all of the expertise and specialized facilities to carry a national program of this magnitude on its own.

Very few colleges of engineering have the resources to acquire and maintain modern state-of-the-art production tools and equipment. Visits to campus facilities reveal the inadequacies of these instructional laboratories. The full-scale equipment, if any, tends to be outmoded production equipment that has outlived its usefulness or "bench-scale" equipment that simulates real environments. Upon graduation, an engineer trained in such laboratories has to adjust to an astonishingly impressive technological environment. Field trips and videotapes are poor substitutes for this transition.

The Manufacturing Research Center at Georgia Tech is an example of a step in this new direction. The facility is housed in a 120,000 square foot building complete with high bay areas and load bearing surfaces adequate to support full-scale equipment. It is modular and designed to be extremely flexible in creating manufacturing environments that will permit research in technologically innovative methods for the design and production of goods that can satisfactorily compete in the marketplaces of the world.

The State of Georgia provided $15-million for this initiative to be matched by another $15-million from industry. Although not yet completed, four corporations have already each committed $1 million over a 5-year period: The research agenda is guided by an Industry Advisory Board to insure relevance and need for the research. Office and laboratory space has been allocated for occupancy by engineers from the supporting companies who will be working with the Georgia Tech faculty, students, and researchers in this collaborative learning environment.

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[1] *Challenges*, Council on Competitiveness, Vol. 4, No. 2, January 1991.

In order for this collaborative initiative to achieve a high level of credibility it must generate new products and new process opportunities for the industrial partners and textual material for the academics. Companies supporting classified research will accrue possession of their proprietary work. At the same time generic knowledge that can be published and shared with industry in general will also be produced. To achieve these ends and to open the door especially to small and medium size companies, conferences, seminars, workshops and demonstrations will be developed that incorporate the developments in computer science and telecommunication technologies in bringing the classroom to remote areas.

The industrial sector cannot be expected to continue to develop educational programs that add to their cost of doing business in an effort to make up for the deficiencies in academic programs. Federal support in the form of matching funds should be made available to industry/university teams jointly preparing and submitting proposals to implement and manage a "learning factory" environment.

The learning environment of a teaching factory would not only expedite the transfer of technological developments into industry but would generate the textual material for the codification of new knowledge and its assimilation into institutions of higher learning. In addition, the experience of the students, technicians, and support personnel working in the micro-factory would also be of value in preparing future technicians for careers in operating and monitoring highly automated and computerized manufacturing plants. Developments in sensor technologies will hasten the introduction of "smart" production tools with self-diagnostics and self-correcting capability. An "instrumented" factory with the dual role of carrying research to a demonstration stage while providing a learning environment that cannot be duplicated in a traditional classroom environment is an idea whose time has come.

A recent Department of Commerce publication adds: "In many cases, the development of an emerging technology by industry can be accelerated by joint efforts which may involve government laboratories, universities, and university research centers. These joint efforts are especially important in addressing elements of the generic technology where no single industry has the resources or the focus to undertake the research and where under-investment in the generic technology would otherwise result." [2]

FUNDING FOR PROOF OF CONCEPT RESEARCH

Traditional funding for university-based research usually falls short of the need to carry the research to a stage of development that would attract venture capital or the corporate investment and commitment necessary to commercialize the discovery. The life cycle of research in manufacturing has three distinct stages:

— discovery
— demonstrated feasibility
— commercialization

If this seems to be somewhat of an oversimplification of the steps necessary to achieve the promises of new discoveries consider the research stages identified by the Department of Defense in developing new weapon systems. The 6.2 budget category was established to promote the exploratory development phase of intellectual developments within DOD science and technology programs and is intended to focus on the most promising of alternative approaches; it is a proof of feasibility stage.

Budget category 6.3A—the advanced technology development stage—supports the development necessary for demonstrating a particular approach to the point where a decision to proceed can be made.

These two budget categories or stages of development exemplify the nature of the applied research that must be incorporated into the cycle of research in manufacturing. A program that can generate demonstrations that could feasibly lead to new or improved products or processes will serve not only small to medium size companies but also the larger corporations with the resources to reach global markets beyond the reach of smaller enterprises. Research that leads to new knowledge adds to the body of knowledge that forms the basis for our modern age of civilization;

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[2] *Emerging Technologies: A Survey of Technical Economic Opportunities*, Technology Administration, U.S. Department of Commerce, Spring 1990.

research that is carried to the applied level, however, can accelerate the process of serving immediate needs for survival in the world marketplaces or for improving the quality of life. A feasibility stage of development can advance the new knowledge to a point where additional work can lead to the fulfillment of a need—a point that will be quickly recognized by business and industrial executives and serve as an incentive for possible investment by the private sector.

A case can be made that a university environment for manufacturing related research will provide an intellectually neutral environment for breaking out of the inbred mold of problem solving that can occur in those enterprises that have the resources to undertake research internally. The R&D facilities, the expertise of the researchers, the mind set that tends to reward success based on traditional, well-known processes and product lines create difficult hurdles to be innovative. Indeed, the reward system of bonuses, pay, and promotion tends to further discourage straying too far from these core competencies that made the enterprise a success in the past.

The next wave of industry/university relations must be based on partnerships that encourage more closely knit collaborative relationships that are mutually beneficial. Support for educational programs in manufacturing need to recognize the overlap of research and new knowledge for the preparation of textual material and the need for Federal funds to support this transition.

LIFE LONG LEARNING INFRASTRUCTURE

Support for manufacturing engineering programs should go to institutions with successful outreach programs. The transfer of technological developments requires an in-place education extension capability in order to keep up to date the competence of scientists and engineers in practice. As mentioned previously, corporate America assumes a major portion of this responsibility, thereby adding to the cost of doing business. A joint effort taking advantage of multi-media based technologies capable of two-way interaction via satellite, cable, or line-of-sight transmission is a practical option to campus-based educational programs. Small and medium size companies in a local area can share reception facilities, further reducing the cost of the programs. There should be equal opportunity for everyone regardless of their location to stay abreast.

GRADUATE-LEVEL COOPERATIVE PROGRAMS

New initiatives such as a graduate-level cooperative program that permits a student to work for a period of 1 to 3 years within a company while satisfying his thesis or doctoral dissertation requirements should receive the backing of several Federal agencies (e.g., Department of Education, National Science Foundation, Department of Defense, National Institute of Health). The intellectual contributions of graduate students whose study and research is monitored by an academic advisor and a supervisor in an industrial R&D organization is a highly effective technology transfer process that needs encouragement and support.

Typical undergraduate co-op programs—though successful in meeting their objectives—do not permit the allocation of time and effort that is necessary to produce advances in new products or manufacturing processes. The graduate co-op program has been designed to fulfill this need. At the present time 267 students are pursuing master's degrees in this program and over 100 are completing their doctoral programs.

In summary, there should be matching Federal funds to support State and industry efforts in undertaking innovative initiatives to improve manufacturing engineering educational programs. This support should be substantial and sustained in order to meet the demands of producing quality goods in a technologically advanced manufacturing environment.

Not all institutions of higher learning can be expected to marshal the multidisciplinary resources or conduct the "proof-of-concept" type of research that will be required. Therefore, Federal resources must be judiciously allocated to achieve the highest return in the shortest time.

An education in manufacturing engineering, like many other fields of intellectual endeavor, does not cease with the granting of a degree. Life long learning programs must be developed and fostered by the academic community in partnership with industry and business. The billions that U.S. corporations are currently spending on internally managed educational programs may be more effectively channeled into partnerships whereby institutions of higher education can perform what they do best—research and teach; and corporations can focus their efforts on what they can do best—produce, market and distribute.

Senator BINGAMAN. Thank you very much. Professor Bowen, why do you not go ahead.

STATEMENT OF H. KENT BOWEN, FORD PROFESSOR OF ENGINEERING, CO-DIRECTOR, LEADERS FOR MANUFACTURING PROGRAM, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. BOWEN. Thank you, Mr. Chairman and Senators. First I would like to indicate the pleasure to be here with my esteemed colleagues, and indicate that I agree fully with the statement of Dr. Thomas and his assessment. I want to focus on the need for some leadership, both from the government and from industry, and from us academics.

The global marketplace, as we now understand it, the access almost universally to ideas and technology, the way industrial sectors become cross-fertilized, and above all, this new dimension of competition called time, has irrevocably changed the world of manufacturing as we know it. The world out there is just not the way we would like it to be from our memories of the past. As a result of this, and it is perhaps vital as we think about this subcommittee, the vitality of the defense industry has become synonymous with the vitality of the whole U.S. industrial base. These two are now so interlinked that we cannot talk about one without talking also about the other.

Let me portray a scenario being played out right now by one of the largest information technology firms in Japan. Its products include telecommunications, computers, and components technology. A senior managing director of the firm described to me the organization's strategy when I visited a few years ago. This company, which already has more engineers per capita than its U.S. competitors, plans to raise the skill and knowledge levels of its blue collar work force to the levels of engineers working in its plants. The company believes that 85 percent of its work force has the desire to reach this new level of competence in performance and is also capable of doing so.

Now just imagine competing with a manufacturing firm that operates by putting its employees knowledge, especially knowledge at this level, first and its physical assets second. A firm in which innovation and incremental improvement can occur throughout the total enterprise both in the product/process conception, in its design, and in production. And let me also remind you that this firm is no slouch. It has the financial resources to back up these intellectual choices and opportunities.

The world marketplace is operating according to a new paradigm of competition, yet aspects of our Nation's system, including features of its education, industry, and government, still hold to old paradigms. If we look at education, our ability as universities to help our youth meet their potential is hampered because of the incapability of the graduates of our high schools. For similar reasons the commercial sector and the defense industry cannot respond to these new competitive challenges, this new world exemplified by this Japanese information technology firm. In general across this country upgrading 85 percent of the American factory work force to function as engineers is really inconceivable without massive re-education, and in most cases or at least many cases, starting at the fundamentals of reading, writing, and arithmetic.

You know the story. A new plant is to be built somewhere in America. The company searches, interviews, and tests for highly skilled workers, finding often less than 10 percent capable of working in a modern production environment. Yet regardless of whether the firm produces high tech or low tech products, to be competitive it must use high technology production processes. High technology production processes require well educated operators.

Perhaps the most difficult facet of the American infrastructure to change is this educational system. On the one hand it is the long cycle time for determining the success of changes in this K through 12 education system. On the other hand it is its diffuse nature and structure, and the possible solutions and implementation. I suspect it will require non-traditional approaches.

Rather than dwell on that feature that sometimes seems intractable, I want to start from the premise that there are perhaps some critical processes that we could begin, some things that could go in effect now and have an impact. And it is my opinion, as stated by Dr. Thomas also, one urgent necessity apparent from examining what is occurring in U.S. manufacturing firms, is the need for manufacturing leadership, technically educated leaders who understand products, have a deep insight about products, the things they make, and about the manufacturing processes, all of the things that Dr. Thomas talked about.

The way to achieve manufacturing leadership is by developing these enterprise engineers, technically based doers and leaders working in America's manufacturing enterprises. What do they do? They implement technology. They conceive and build products, they conceive and build plants and distribution systems, and they help lead and improve their firm's human and organizational systems.

My own experience, then, leads me to believe that the way we can dramatically improve the defense industry and its complementary commercial sector is by investing in education and research, invest in the education and the research to produce this new breed. I think that is what you are going to hear from all of us.

Now, how did I reach this conclusion? First I want to remind you what engineering is. First, what it is not. Engineering is not science. If we look at all of the wonderful things that engineering has done for society in the past, whether it is in public works or in products, engineers pull science and technology together to do things useful for society. That is what engineering is all about. And in some cases in the past in our narrow discipline we tried to perhaps mimic science too much, and I think that is again the message you are getting here, that we need these people, these integrators of the science and technology for society's benefit.

This experience base comes from the results of that 2-year study by the M.I.T. Commission on Industrial Productivity. I remind you we examined eight industrial sectors, very different kinds of sectors, automobiles, machine tools, chemicals, commercial aircraft, consumer electronics, textiles, steel, semiconductors, computers, and copiers. And we also looked at the education and training systems in the United States and also in our principal competitors. So

I have this base and then the last number of years working intimately with 11 U.S. manufacturing firms to develop an educational program.

Let me first remind those of you who are unfamiliar with this M.I.T. commission's findings what they were. We found that there is an impact of the U.S. manufacturing base well beyond the macro numbers that are tracked by the Defense Department or the Department of Commerce. Most of the private R&D in this country is done in fact by the manufacturing companies. And what we found, without a doubt, that if we intend to live well, to enjoy the standard of living that we have had in the past, we have to produce well. And we have neglected, both in our educational systems and what we do at the government level and in the companies, this production part. There is no way around it.

We identified in that study six recurring patterns of weaknesses. Outdated strategies, short-time horizons, technical weakness in development and production, neglect of human resources, failures of cooperation, and government and industry often at cross purposes. Our simple recommendations to this committee, if followed, would, I believe, alleviate many of these weaknesses that we identified.

Another of that commission's results was the fact that we identified five imperatives that we had to get on with, and these of course involve industry, academia, and government. We need to begin focusing on producing well by putting production ahead of finance and monetary manipulations. Second, we need to cultivate a new economic citizenship by developing an involved, educated, responsible, and a rewarded work force. We need to promote the most productive blend of the American individualism with cooperation in all aspects of trade and industry.

And we need to learn to live in this world economy. Our students do not speak foreign languages to the degree that they did perhaps 20 or 30 years ago. We do not understand those foreign cultures and technology. And then finally, provide for the future by this investment in education, and I think we would all agree, do not confuse training, which is band-aids, with education, the fundamental knowledge that will empower people for life-long learning and to adjust in this dynamic world we live in. And also providing for the future by saving for productive investment. These weaknesses, these five challenges and imperatives, will need to involve all three, the government, industry, and academia working together.

We took that dilemma which was presented and used it as a mirror to look within our own educational institution, to do something at M.I.T. that might be meaningful. And to do that, the process was to ask the people we are trying to help. Ask the U.S. manufacturing firms who are being clobbered by their foreign competitors, ask them what we might do to help. And when we did that, after a long process, a lengthy process of self-examination, we developed our program and our response.

These companies that we asked to help us all have different corporate cultures, they have different technology bases, they serve different markets. Most of them participate in commercial, industrial and defense sectors. And interestingly, the agenda that they gave us was not one of silver bullets, a piece of technology. What they gave us for an agenda was an educational agenda and a knowledge generation agenda.

So these companies, Alcoa, Boeing, Chrysler, Digital, Eastman Kodak, General Motors, Hewlett-Packard, Johnson & Johnson, Motorola, Polaroid, and United Technologies told us our mission, working together as a partnership, was to identify, discover, and translate into practice (the doing), the critical factors that underlie world class manufacturing, in a way that attracts potential leaders, to attract the best and the brightest. The best and the brightest need to produce in a way that establishes and verifies a new set of principles and practices for manufacturing, in a way that stimulates new and innovative modes of collaboration between industry and academia, and establishes a high level of cooperation and collaboration. We cannot afford in today's competitive world to all reinvent the wheel. We need to share these resources.

It is interesting that this group put on the wall the products of our program, and those products are: graduates, a curriculum, redefine what it means to have a career in enterprise engineering, define these collaborative processes in which people move back and forth from the industrial sector to academia and vice-versa.

What does it mean to have a manufacturing faculty, this diverse group that Dr. Thomas talked about? And how do you do this interdisciplinary research that is very much a new agenda for most universities? It is a big challenge to have an engineer working with someone in organizational behavior and psychology, but maybe it is that combination that discovers the keys to make America productive again.

Let me summarize with some comments and indicate what this implies. If the government wants to join with academia and industry they have from us the input, the consensus of what industry is clamoring for and what universities are coming up with to work with industry. But to do this, to make it work we need the government's help. For productivity and competitiveness we need to invigorate the university and college programs devoted to educating these enterprise engineers. These institutions need funds that turbo charge their involvement with manufacturing firms.

Of particular critical concern is the educating of the best and the brightest that not only do the inventing of the science, but who take positions in manufacturing process development, manufacturing engineering and manufacturing operations. We need the resources, the government needs to help provide the resources for the codification and discovery of these manufacturing principles, because it will have not only an impact with the universities, but this is the material that can impact the installed capacity, all of those people who have been trained or educated with the old paradigm.

We need an opportunity to have prestigious and focused scholarships and fellowships to attract the best and brightest to this field. And finally a by-product of this exercise, I believe, will be the education of a new generation of doctoral students to become the faculty of the future that in fact develop the future for us in our universities.

In our Leaders Program at M.I.T. we were very fortunate, very lucky to have the intellectual and financial support of some of America's finest companies and their most visionary people. We are universally excited and sometimes even awed at the opportunities created by the program and its successes. Quality people, armed with knowledge and other necessary resources, can be the determinants of excellence. And world class, best of the best, cannot only be our goal but actually can be our achievement. It is within our purview if we properly exercise our distinct leadership roles in government, universities, and industry.

Thank you.

[The prepared statement of Dr. Bowen follows:]

PREPARED STATEMENT BY H. KENT BOWEN, FORD PROFESSOR OF ENGINEERING, CO-DIRECTOR, LEADERS FOR MANUFACTURING PROGRAM, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. Chairman, members of the committee, thank you for inviting me to describe my views on the U.S. educational system and its impact on the defense industrial base—specifically, on ways in which government, industry, and academia might assume leadership roles.

The global marketplace, the almost universal access to ideas and technology, the cross-fertilization of industrial sectors, and above all, the critical competitive dimension of time have irrevocably changed the world of manufacturing. One result is that the vitality of the defense industry base has become synonymous with the vitality of the U.S. industrial base, the two being interlinked and interdependent with respect to firms, organizations, people, infrastructure, knowledge bases, and educational/training systems. The defense industry relies so heavily on the breadth and depth of the commercial base that issues affecting the latter are also defense issues.

Let me begin by portraying a scenario being played out right now by one of the largest Japanese information technology firms; its products include telecommunications, computers, and components technology. A senior managing director of the firm described to me the organization's strategy when I visited a few years ago. This company—which already has more engineers per capita than its U.S. competitors—plans to raise the skill and knowledge levels of its blue-collar work force to the levels of engineers working in its plants. The company believes that 85 percent of its work force has the desire to reach this new level of competence and performance and is capable of doing so. Now, imagine competing with a manufacturing firm that operates by putting its employees' knowledge first and its physical assets second; a firm in which innovation and incremental improvement can occur throughout the enterprise in product/process conception, design, or production. Finally, this firm has the financial resources to back up its intellectual choices.

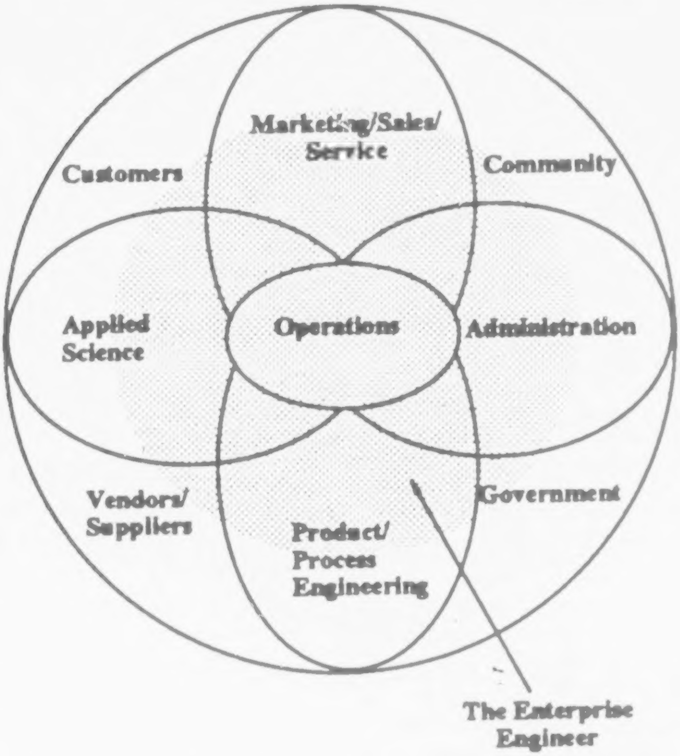
The world marketplace is operating according to new paradigms of competition, yet aspects of our Nation's system, including features of its education, industry, and government, still hold to old paradigms. Let's consider education for a moment. The ability of American universities and colleges to fulfill their missions and help our youth reach their potential is drastically impaired by the abilities of high school graduates.

For similar reasons, the commercial sector and the defense industry cannot respond to the new competitive challenges exemplified by the Japanese information technology firm just described. In general, upgrading 85 percent of the American factory work force to function as engineers is inconceivable without massive re-education; in many cases, this would require starting with the fundamentals of reading, writing, and arithmetic. You know the story well: a new plant is built and the company searches, interviews, and tests for highly skilled workers, finding less than 10 percent of the applicants capable of working in a modern production facility. Yet, regardless of whether a firm produces high-tech or low-tech products, to be competitive, it must use high-tech production processes, which require well-educated operators. Perhaps the most difficult facet of the American infrastructure to change, however, is its educational system. The long cycle time for determining the success of changes to K-12 education, along with the diffuse nature and structure of possible solutions and implementation, require nontraditional approaches.

Rather than dwell on our Nation's intractable K-12 problems, therefore, I would like to take as my starting premise the possibility that there are identifiable, critical processes that can get us on the right road, right now. In my opinion, one urgent necessity apparent from an examination of most U.S. manufacturing firms is *manufacturing leadership:* technically educated leaders who understand products and manufacturing processes. The way to achieve manufacturing leadership is by developing *enterprise engineers*—technically based doers and leaders working in America's manufacturing enterprises—to implement technology, conceive and build products and plants, and help lead and improve their firm's human and organizational systems.

The conclusion I, through my research experience, have arrived at, then, is that the surest way to dramatically improve defense technology and industry and its complementary commercial sector is by investing in education and research to "produce" enterprise engineers. Let me review how I reached this conclusion. First, some clarification of the term "engineering" may be in order. If we consider a few outstanding examples of the past, whether they be in public works, the commercial sector, or the defense sector, we can start to recognize what engineering can be. Engineers use science and technology for the benefit of society. Engineering, for our discussion here, is the confluence of science and technology to yield products and production systems for society.

The Manufacturing Enterprise



Now, on to the bases for my comments: First, the results of a 2-year study conducted by the MIT Commission on Industrial Productivity,[1] examining eight industrial sectors (automobiles, machine tools, chemicals, commercial aircraft, consumer electronics, textiles, steel, and semiconductors/computer/copiers) as well as education and training programs in the United States and its principal competitors; and second, my intense interactions over the past 4 years with 11 U.S. firms to establish a research and educational program to produce leaders for manufacturing firms. My intent here is to convey facts and ideas that will enable you to make better decisions as you implement legislation to improve the Nation's productivity and its competitive position—I especially wish to emphasize the value that must be set on people, knowledge, technology, and other infrastructural issues.

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[1] Michael L. Dertouzos, Richard K. Lester, Robert M. Solow, and the MIT Commission on Industrial Productivity, *Made In America: Regaining the Productive Edge*. The MIT Press, Cambridge, Massachusetts (1989).

First, a consideration of the MIT Commission's findings. The impact of U.S. manufacturers on the economic and social well-being of the Nation goes well beyond the macronumbers tracked by government departments—well beyond the fractions assigned as contributions to GNP or as military purchases. The MIT Commission, of which I was a member, concluded that the impact of manufacturing on our society is very broad; manufacturing firms, for example, are the major sponsors of private RD/E—and thus of future economic development. In short, if the U.S. intends to live well, it must produce well. There is no other way!

The MIT Commission identified six recurring patterns of weakness in U.S. productivity performance: outdated strategies, short time horizons, technological weakness in development and production, neglect of human resources, failures of cooperation, and government and industry at cross-purposes. Our simple recommendations to this committee, if followed, would assist in alleviating some of these identified weaknesses.

Another outcome of the Commission's study was its elucidation of five imperatives for the Nation's Government, educational systems, and companies. Because of their interdependence, all five must be addressed or we will pay a severe penalty. To continue as a major economic power, the Commission determined that the U.S. must:

1. *Focus on producing well*—by putting production ahead of finance and monetary manipulation.
2. *Cultivate "a new economic citizenship"*—by developing an involved, educated, responsible, and rewarded work force of people who will maximize productivity and provide themselves with greater job satisfaction.
3. *Promote the most productive blend of individualism and cooperation*—in all aspects of trade and industry.
4. *Learn to live in the world economy*—by striving to understand other languages, cultures, and technologies.
5. *Provide for the future*—by investing in education, and saving for productive investment.

The six weaknesses, identified by the Commission, which are generally ascribed only to our manufacturing enterprises, and the five imperatives to be implemented also impact our universities, as well as our primary and secondary educational systems. Even though our higher education system is revered throughout the world as being the very best, universities obviously have a role in the productivity-competitiveness equation. Let's therefore consider next what our universities can do to address productivity and competitiveness—which, brings us to the second basis for my personal conclusions about the importance of developing manufacturing leadership in this country: my interactions with manufacturing companies through the Leaders for Manufacturing Program.

If you were a U.S. manufacturing firm not just trying to survive, but to lead in the global economy, what might you ask a university to do? We asked this question of 11 U.S. firms serving different markets, relying on different technologies, and characterized by different corporate cultures and structures. Many produce for commercial, industrial and defense markets. After months of deliberation, analysis and strategic planning, the Leaders for Manufacturing Program was conceived and implemented as a partnership by MIT and 11 manufacturers: Alcoa, Boeing, Chrysler Motors, Digital Equipment, Eastman Kodak, General Motors, Hewlett-Packard, Johnson & Johnson, Motorola, Polaroid, and United Technologies.

The purpose of the Leaders Program is to identify, discover, and translate into practice the critical factors that underlie world-class manufacturing in a way that:

- attracts potential leaders with a global perspective and develops them to bring about world-class manufacturing
- establishes and verifies a new set of principles and practices for manufacturing
- stimulates new and innovative modes of operation for academia and industry
- achieves a high level of cooperation between academia and industry to integrate the technical, managerial, human, and organizational dimensions of manufacturing
- establishes ongoing collaborative processes for problem identification, discovery, and knowledge transfer

The Partnership has proposed that, to be successful, it must yield from the people, facilities, and funds made available by MIT and the 11 companies seven principal product outputs: graduates, curricula, careers, collaborative processes, manufacturing faculty, interdisciplinary research, and knowledge dissemination and implementation.

It is important to note what the companies have identified as being in their common good: outputs to make themselves and other firms more productive and competitive. None are quick fixes, silver bullets of technology, or mere structural changes to their organizations. Their assessment relates to dealing with the complexities of the socio-economic manufacturing world; it focuses on leadership, change, and the proper role for technology and non-technology solutions.

If the Federal Government wants a consensus suggestion as to what constitutes leadership in academia and industry to strengthen the Nation's industrial base, I honestly believe this represents the one surest to make lasting progress. I strongly believe this subcommittee and others should learn from the people all of us are trying to help: our manufacturing firms, whose job has never been more difficult than it is today. Truly world-class performance is achieved by only a few that can do it all with excellence.

I would like to end this testimony by offering a few suggestions for you to consider as you hammer out government's leadership role in the productivity/competitiveness equation.

1. Invigorate university and college programs devoted to educating enterprise engineers. These institutions need funds to turbocharge their involvement with manufacturing firms. A particularly critical concern is educating the best and brightest engineers to take positions in manufacturing process development, engineering, and operations.

2. Provide resources for the codification and discovery of manufacturing principles to provide the knowledge from which academic and corporate curricula can be developed. Traditional and nontraditional research and scholarship are needed to transform the typically ad hoc nature of operating the enterprise and of teaching manufacturing to something more systematic, being based on principles and underlying the new discipline of manufacturing.

3. Provide prestigious, focused scholarships and fellowships to educate undergraduates and graduates in the new manufacturing discipline. At the post-baccalaureate level, the most accomplished engineers need to be attracted to the field, to learn aspects of manufacturing and enterprise engineering that will empower them to contribute to our knowledge base and lead change in U.S. manufacturing firms.

4. Finally, a necessary by-product of the first three suggestions will be the education of a new generation of doctoral students who can become enlightened faculty in engineering and business schools, promulgating the new manufacturing discipline to other institutions and graduates and thus, increasing the number of people able to improve the Nation's industrial and defense productivity.

In conclusion, the Leaders Program has been extremely fortunate to have garnered the intellectual and financial support of some of America's finest companies and their most visionary people. We are universally excited—sometimes even awed—at the opportunities created by the program and its successes. Quality people armed with knowledge and other necessary resources can be the determinants of excellence. And world-class, "best of the best" can be not simply our goal, but our achievement. It is within our purview if we properly exercise our respective leadership roles.

Senator **BINGAMAN**. Thank you very much. Dean Yang, why do you not go ahead.

STATEMENT OF HENRY T. YANG, DEAN OF ENGINEERING, PURDUE UNIVERSITY

Dr. **YANG**. Thank you, Senator Bingaman. It is a distinct honor and a pleasure to appear before you today to discuss the role of higher education in relation to defense industry and technology. A few of our leading universities, including those of Dr. Bowen and Dr. Thomas, have instituted special programs to supply the "best and brightest" to the technical work force of America. These programs provide encouraging examples to indicate what can be done, and the lessons we learn from them can be generally applied.

As you know, industrial competitiveness has been a major concern around the country. The ability of a nation to defend itself, both militarily and economically, is related to the nation's command of technology. This, in turn, is related to the abilities of people to understand, create, and implement advanced technology. It is the technically oriented universities that prepare a large fraction of the scientists and engineers for such responsibilities. It is, therefore, appropriate for your committee to inquire into our activities. Clearly, universities can be only part of the solution to the national competitiveness problem, but they are an important part. Technical education is a keystone of the solution. In a real sense, niversities are incubators for whatever advanced technology capabilities we will have over the next half century and beyond.

Twenty years ago American dominance in technology was taken for granted. Our success in the space program and the arms race, and other visible technical accomplishments, led us to believe that we were equally strong in all areas. In particular, most universities paid less attention to education in manufacturing. They thought our leadership in manufacturing was so secure that we could afford to focus on other needs. This is a story I am sure you all know. However, at Purdue and a few other leading research universities, we did recognize the need for change. We began reforms more than a decade ago. Those reforms are now bearing fruit.

I would like to share with you some of the lessons from our experience. At Purdue we realized in the early 1970s that we needed to broaden the base of students from which we were drawing. Women and minorities were grossly under-represented in our student body. We initiated many innovative programs to interest them in science and engineering. We also searched for ways to recruit and retain them. Today our efforts to attract women and minorities begin as early as grade school.

Our methods have been somewhat successful. Over the past decade Purdue has granted 3,000 engineering degrees to women. This is more than any other university in the Nation. Furthermore, Purdue was recently ranked by U.S. Black Engineer magazine as one of the top 10 institutions in the Nation in granting B.S. engineering degrees to African Americans. Of course both M.I.T. and Georgia Tech have strong reputations in these areas as well. We still have a long way to go yet, and we continue to emphasize these programs. America's future industrial competitiveness will require cultural diversity, as well as technical excellence in our engineering work force.

Another responsibility of major technical universities is research and development of new manufacturing technology. Ten years ago, we at Purdue began working intensively on these issues. We collaborated closely with a few manufacturing companies. The idea was to develop a university research effort that could focus on real industrial problems. We created a small research center funded entirely by industrial companies. The first few years were difficult as we struggled to find a common language, establish working principles, and focus our objectives.

We soon learned that the traditional organization of a university creates hurdles for manufacturing research. Our universities are organized into departments based on separate disciplines, but solving real industrial problems demands a team approach to research. The boundaries between academic departments created barriers that were difficult to overcome, much like the barriers between divisions in industry or agencies in government.

With our new center, however, we were able to overcome these barriers to some extent. We initiated a cross disciplinary approach. We pulled together teams of students and faculty members from different disciplines. They attacked complex technical problems from real manufacturing situations. Once we had achieved this teamwork among academic departments and with industry, we began to make significant progress. We successfully addressed challenging problems. However, we were handicapped by our size. The effort was simply too small to have much effect either on the university or on the companies we were working with.

Fortunately, in 1985 the National Science Foundation established a special program. It was designed to help American industry become more competitive. The program established what are called Engineering Research Centers, or ERC's, at several leading universities across the country. Purdue was one of the first of these universities selected as an ERC site. Our ERC is called the Center for Intelligent Manufacturing Systems. Working with eminent colleagues, able center director, Jim Solberg, and our visionary university president, Steven Beering, I have had the opportunity to be deeply involved in the Purdue center from the beginning, and I have closely observed the progress and accomplishments of the ERC program, both at Purdue and at other universities, since its inception.

The ERC's are set up to achieve several goals. First, they are specifically structured to address issues that are critical to industrial competitiveness. Research is driven by identified and anticipated industrial needs. Companies participate directly in our research. They work with faculty and students from across the traditional disciplines. Another specific objective of the ERC's is the creation of a new intellectual climate. This climate encourages teamwork and the so-called "systems approach" to complex problems.

A profound change has occurred at those universities where ERC's are located. Some have called it a "change of culture." It would be better to call it an "enrichment of the culture," because we are really adding to existing strengths in research and educational programs. These existing programs are still the envy of the world. In the enriched culture, faculty members are working closely with partners in industry. This provides direct and indirect benefits to both sides. Research results flow from university laboratory into industry more smoothly. Researchers are more aware of the real needs of industry, and they are more able to anticipate the future needs of industry. Furthermore, the educational process itself is improved because our students are exposed to this multidisciplinary team approach.

Individual ERC's and the program as a whole have been closely scrutinized. Quality and performance have been evaluated from the very beginning. The original selection process involved a series of panels and peer reviews. It was extremely competitive. Subsequent studies have been conducted by the National Academy of Engineering, the Government Accounting Office, numerous internal reviews, and site visits by distinguished representatives of industry, government, and academia. The general conclusion from all of these reviews is that the experiment has been a great success.

From the standpoint of cost effectiveness, the ERC programs have achieved a large effect with a relatively small financial investment. The pooling of public and industrial funds and the accompanying pooling of ideas and efforts produce highly leveraged results. I believe the mix of Federal and industrial funding is healthy and appropriate.

Let me give you one example of the kind of research the ERC program has enabled. At Purdue a team of faculty and students from different disciplines worked together with engineers from several of our partner companies. They created a novel system for designing and machining metal parts. They called this new system the Quick Turnaround Cell. The system enables a manufacturer to produce one-of-a-kind parts in minutes instead of the several weeks that would normally be required. The system is now being installed at the Army Missile Command in Huntsville. It is also being considered for commercial development for several companies. This example illustrates what can be accomplished when a team of students, faculty, and practicing engineers combine their talents, imagination, and energy on a real industrial problem.

This success leads me to conclude that, in order to have a large impact on the Nation's industrial practices and the educational pipeline, there should be more such centers. The ERC program of the National Science Foundation, the Department of Defense University Research Initiatives, and other similar programs provide some excellent models of how this can be done. Although it was wise to start with just a few, I think we now know enough to go about this in a more substantial way. Experience has shown us that high quality programs such as these centers require stable support from the government for a sustained period of time.

I also conclude that existing centers can do more. Many of the ERC's have developed new concepts which now are ready to proceed to the next stage in their development. We might call the next stage "functional prototyping." A functional prototype is a working version of a new technical concept. Functional prototypes would provide private industry with proof of the viability of new concepts. They would also furnish a rational basis for a business decision to develop or adopt the new technology. Functional prototypes could help fill the gap between what universities can do and what private industry can do based upon profit incentives.

I would like to say something about education in general. The American system of higher education is regarded as the best in the world. This has been correct, but to maintain this position of world leadership we must have a healthy primary and secondary educational system. We must strengthen math and science education at the K through 12 levels. This is crucial for two main reasons. First, to ensure that our college students are well prepared for what we can offer them at the university level. And second, to improve the quality of America's work force in general. The factory worker of the future, like workers in every other sector of our economy, will need marketable skills to remain employable. The standards for these skills are rising.

Our country must not fail to develop the full technical capabilities of all our young people. This is especially true of women and minorities, who have traditionally been under-represented in science and engineering. Their fair representation would mean a significant increase in our Nation's power in industrial competitiveness. I would recommend more government funding for fellowships to inspire more minorities and women to pursue science and engineering education at both the undergraduate and the graduate levels.

In closing, I would like to emphasize that our most important products are our students. Our number one asset is not the technology that results from our efforts. It is the minds of the students in our classrooms and laboratories. We in the universities have the opportunity to influence bright young people at an important time, the time when they are choosing their careers. This choice is important to the individual, but it is important to the Nation as well. I hope we can inspire more students to turn their talents to science and engineering so we can prepare them to help American industry improve its competitive edge.

I cannot think of anything more vital to the long-term security of America. Thank you.

[The prepared statement of Dr. Yang follows:]

PREPARED STATEMENT BY HENRY T. YANG, DEAN OF THE SCHOOLS OF ENGINEERING, PURDUE UNIVERSITY

Mr. Chairman, it is a distinct honor and pleasure to appear before this committee to discuss the role of higher education in relation to defense industry and technology. My name is Henry Yang. As dean of engineering at Purdue University, I have the honor to preside over one of the largest engineering education programs in the country. I am pleased to join Dr. Kimmel and Professors Bowen and Thomas appearing before you today.

A few of our leading universities, including those of Dr. Bowen and Dr. Thomas, have instituted special programs to supply the "best and brightest" to the technical work force of America. These programs provide encouraging examples that indicate what could be done, and the lessons learned can be generally applied.

As you know, industrial competitiveness has been a major concern not only in Washington, but around the country. The ability of a nation to defend itself both militarily and economically is directly related to its command of technology, which is in turn directly related to the abilities of people to understand, create, and implement advanced technology. Since it is the technically oriented universities, such as those represented here today, that prepare a large fraction of the scientists and engineers for such responsibilities, it is appropriate for your committee to inquire into our activities. Clearly, universities can be only part of the answer to the national competitiveness problem. But, technical education is a keystone of the solution. In a very real sense, universities are incubators for whatever advanced technological capabilities we will have over the next half-century and beyond.

Twenty years ago, almost everyone took American dominance in technology for granted. Our successes in the space program and the arms race, and other visible technical accomplishments, led us to believe that we were equally strong in all areas. In particular, most universities paid less attention to education in manufacturing, thinking that our leadership in that area was so secure that we could afford to focus on other needs. This is a story I am sure you know. However, at Purdue and a few other leading research universities, we did recognize the need to change and began reforms more than a decade ago. Those reforms are now bearing fruit. I would like to share with you today some of the lessons from our experience.

At Purdue, we realized in the early seventies that we needed to broaden the talent base from which we were drawing. Women and minorities, who traditionally have been under-represented in the engineering community, became a priority. We started many innovative programs to cultivate their interest in science and engineering, to recruit them, and to retain them. The cultivation process starts as early as grade school. As a result of our comprehensive efforts, Purdue has graduated 3,000 women engineers in the last decade, more than any other university in the Nation. Furthermore, Purdue was recently ranked by U.S. Black Engineer magazine as one of the top 10 engineering institutions in the Nation in granting bachelor's engineering degrees to African Americans. We still have a long way to go yet, and we continue to emphasize these programs to increase the proportions of the under-represented. Future industrial competitiveness will require cultural diversity as well as technical excellence in our engineering work force.

Research and development of new manufacturing technology, and the foundation of knowledge upon which these activities must be based, are also the responsibility of major technical universities. Some 10 years ago, we at Purdue began working on these issues intensively in close collaboration with a few manufacturing companies. The idea was to develop a university research effort focussing on real problems faced by manufacturing industries. We created a small research center funded entirely by industry. The first few years were difficult, as we struggled to find a common language, establish working principles, and focus our objectives. From the outset it was apparent that the traditional organization of a university into discipline-oriented departments created barriers that were similar to, and as difficult to overcome, as the barriers between divisions in industry or agencies in government. With our new center we were able to overcome these barriers to some extent. We initiated a cross-disciplinary approach, which enabled us to pull together teams of faculty and students from different disciplines to attack complex technical problems that occur in real manufacturing. Once we had achieved this teamwork among the academic departments and with industry, we began to make significant progress on challenging problems. However, we were handicapped by our size. The effort was simply too small to have a big impact upon either the university or the companies we were working with.

Fortunately, in 1985, the National Science Foundation established a special program designed to help American industry become more competitive. The program established Engineering Research Centers, or ERCs, at several leading universities. Purdue University was one of the first of these universities selected as an ERC site. The Purdue ERC is called the Center for Intelligent Manufacturing Systems. Working with eminent colleagues, able center director James Solberg, and our visionary university president, Steven Beering, I have had the opportunity to be deeply involved in the Purdue center from the beginning. I have closely observed the progress and accomplishments of this NSF program, both at Purdue and in other universities, since its inception.

The ERCs are set up to achieve several goals. First, they are specifically structured to address issues that are critical to industrial competitiveness. The research is driven by identified and anticipated industrial needs. It is not limited to the pure intellectual curiosity or the "good science" that are so important to academic research. Companies participate directly in the work, along with faculty and students from across the traditional disciplines. Another specific objective of the ERCs is the creation of a new intellectual climate that encourages teamwork and the so-called "systems approach" to complex problems. This approach is in contrast to research in which an individual scholar explores the frontiers of knowledge in some highly specialized area. Both kinds of research are needed, but problems of modern manufacturing are so complex that they frequently demand the integrated team approach. We need to educate future engineers to be able to fit into a team-oriented environment, because that is the environment in which manufacturing industry operates, and the environment in which students are likely to find themselves after graduation.

A profound change, which some have called a "change of culture," has occurred at those universities where ERCs are located. It would be better to call this an enrichment of the culture, because we are really adding to existing strengths in our traditional approaches to research and education, which are still the envy of the world. Regardless of the label attached to this cultural transformation, the ERCs have produced a new academic research environment in which the disciplines work together to tackle the larger scale and more technically diverse problems that occur in advanced technology today. Faculty members are working much more closely with partners in industry, which provides direct and indirect benefits to both sides. The smooth flow of research results from university laboratories into industrial use, researchers' awareness of the real needs of industry, and their anticipation of future needs, and the educational process itself, are all better served by this new environment.

The quality and performance of individual ERCs as well as the program as a whole have been closely scrutinized. The original selection process, involving a series of panels and peer reviews, was extremely competitive. Subsequent studies by the National Academy of Engineering and the Government Accounting Office, numerous internal reviews, and site visits by distinguished representatives of industry, government, and academia, have thoroughly evaluated the ERCs. The general conclusion from all of these reviews is that the experiment has been a great success.

From the standpoint of cost-effectiveness, the ERC program has achieved a large effect with a relatively small financial investment. The pooling of public and industrial funds, and the accompanying pooling of ideas and effort, produces a highly leveraged result. I believe the mix of Federal and industry funding is healthy and appropriate. It enables the university to carry out effectively its educational and technology transfer roles, which industry funding alone would not accomplish. At the same time, the financial contributions of industrial companies ensure their sustained commitment to the program.

Here is one example of the kind of research that the ERC has enabled. A team of faculty and students from different disciplines, working with practicing engineers from several of our partner companies, created a novel system for designing and machining metal parts. This system, which they called a Quick Turnaround Cell, enables a manufacturer to produce one-of-a-kind parts in a matter of minutes, as opposed to the several weeks that would normally be required. The system is now being installed at the Army Missile Command in Huntsville, and is being considered for commercial development by several private companies. This example illustrates what the imagination and energy of a team of students and faculty, working with the practical guidance of engineers from industry, can accomplish.

This success leads me to conclude that, in order to have a large impact on the Nation's industrial practices and the educational pipeline, there should be more such centers. The ERC program of the National Science Foundation, the DOD University Research Initiatives, and other similar programs, provide some excellent models for how this can be done. Although it was wise to start with just a few, I think we now know enough to go about this in a more substantial way. Experience has shown us that high-quality programs such as these centers require stable support from the government for a sustained period of time.

I also conclude that existing centers can do more. Many of these centers have developed new concepts which are ready for the next stage in development, a stage we might call "functional prototyping." Functional prototypes would be working versions of new technical concepts. They would provide private industry with proof of the viability of new concepts developed at the universities, and thereby provide a rational basis for a business decision to develop or adopt the new technology. Functional prototypes could go a long way toward filling the gap between what universities can do in their laboratories and what private industry can do based upon profit incentives.

I would like to say something about education in general. Although the American system of higher education is correctly regarded as the best in the world, we in the universities can maintain this position only if we have a healthy primary and secondary educational system. We must strengthen math and science education at the K-12 level. This is crucial not only for maintaining our world leadership in science and engineering higher education, but also for improving the quality of America's work force in general. The factory worker of the future, like workers in every other sector of our economy, must possess marketable skills to remain employable. The standards for these skills are rising. Our country must not fail to develop the full technical capabilities of all our young people. This is especially true of women and minorities, who have been under-represented in science and engineering in the past. Their fair representation would produce a substantial increase in our Nation's power in industrial competitiveness. I would recommend more government funding for fellowships to inspire more minorities and women to pursue science and engineering education at both undergraduate and graduate levels.

In closing, I would like to emphasize that our most important product is our students. Our number one asset is not the technology that results from our efforts, but the minds of the students in our classrooms and laboratories. We in the universities have the opportunity to influence bright young people at a time in their lives when they are choosing their careers. It is a time which is of great importance not only to them as individuals, but to the Nation as well. I hope we can inspire them to turn their talents to productive goals, to prepare them to help American industry improve its competitive edge, and to stimulate them to continue that thrust throughout their lives. I can think of nothing more vital to the long term security of America.

Senator BINGAMAN. Thank you. I appreciate all the testimony. What is our greatest need in improving universities like yours? You are among the top flight universities in the Nation and in the world in engineering education. Is that our biggest problem or our biggest area of opportunity? Should we instead concentrate on the larger number of students who attended 2-year schools for example?

We have many thousand 2-year schools around this country which are struggling to provide some level of instruction in these areas as well. Some of them do a very good job, I understand, but many probably do not. Where should we be allocating some of the Department of Defense resources in this area? Do we need to do both? Do we need to improve our ability on both state-of-the-art research on flexible manufacturing, as well as this other, or should we concentrate only on one? Dean Thomas, did you have some thoughts on that?

Dr. **THOMAS**. Well, let me give you a couple of anecdotes. One, GM shut down a plant in Freemont, California because they could not make it work. That subsequently became part of the joint venture between Toyota and General Motors. Toyota came in and hired 80 percent of the work force that had been there before. That is now the most productive plant that GM or Toyota have.

I am not—clearly it is a concern, and as we get more and more technologically advanced we are going to have to have people who can deal with that. But I think the issues of dealing with the work force are more managerial rather than technological issues.

Senator **BINGAMAN**. You do not think that the concentration is needed at the lower levels in the educational hierarchy? You think that our greatest concern is remaining world class and having the capability in our top institutions to do the research that is needed?

Dr. **THOMAS**. I think that there are many avenues for improving the capability of the people on the production lines. We need to address those issues because they are going to have to be more technologically competent in the future than they have been in the past. They are going to have to be lighter on their feet. But if we are going to regain a competitive edge in our manufacturing activities, I think money has to be invested at the top of the system, because technology is changing very, very fast and if we do not get our engineers and scientists in a position where they can adapt to very rapid changes in technology, we will not be in a position to compete, even if we have a good work force.

Senator **BINGAMAN**. Professor Bowen or Dean Yang, did either of you have a thought on this?

Dr. **BOWEN**. I would agree from the sense that I think we need people out there who have a vision of what the world is becoming, so that there is a place for those trained in the 2-year community colleges and those with a high school education, so we can get on with the manufacturing engineering, the enterprise engineering now, because those others have longer development cycles to get them fixed. And so by taking a parallel approach I think we can survive. But I do concur that the K through 12 problem is very severe, as is the education of the technician level, the community college, vocational education issues.

Senator **BINGAMAN**. Dean Yang, did you have any thoughts on this?

Dr. **YANG**. Well, I think high technology and international competitiveness are so important that we should emphasize the high tech research in manufacturing, but I also think that the research-oriented institutions have some responsibility to help the Nation improve K through 12 and community college engineering and manufacturing education.

Senator **BINGAMAN**. Okay. What about the Intelligent Manufacturing Systems Proposal the Japanese have made to us? Is that something we should be pursuing aggressively? My sense is that we are basically stalling. I believe we have some industry that is interested in going ahead there, but I gather we have now told them we want to study the issue for about another 18 months to see whether there is anything we can learn from the Japanese in manufacturing. That is my paraphrase of our position. Do any of you have a point of view as to whether we should be more aggressively pursuing the opportunity for international cooperation that is set out in that initiative?

Dr. THOMAS. Well, I think we have got to become as proactive in understanding Japanese manufacturing systems as they have become in understanding ours. We were talking before we came in this morning among the three of us, and it is clear that the Japanese firms are much more involved in our universities than is the case with U.S. firms. They devote a tremendous amount of time and effort in understanding to what is going on in U.S. universities, to their benefit.

Also I think it is the case that the Japanese have targeted certain industries, one at a time or several at a time, that they are going after. And they have managed to take over much of the world's production in these industries. We have seemed to shy away from an industrial policy in this country, and in fact have sort of chopped the hands off of people who have attempted to implement industrial policies in their own private little preserves that they have had. I am not sure that that is wise for us to do that, because that is not the way it is being done by the Japanese or the people in Europe. And they are targeting the next generation things that they are going after. And we are sort of leaving our manufacturing and industrial firms to compete with large consortium efforts between government and manufacturing firms in foreign countries, and they have got tremendous resources to bring to bear. We are not fully utilizing all of our talents.

Senator BINGAMAN. Dean Yang, did you have a comment on this?

Dr. YANG. Well, this initiative has exactly the same name as our Center for Intelligent Manufacturing Systems.

Senator BINGAMAN. I noticed that. They copied that from you. You should sue them.

Dr. YANG. I would imagine so. We think we ought to proceed with great caution. The Japanese are very good at knowing, learning from our technology. I think they are kind of like the decathlon player. In each area they just need to be second or third, but when combined together they come out ahead and are pretty good in manufacturing. But, this Nation's science and engineering base is deep and broad. We have tremendous capability.

When we work with the Japanese, sometimes we feel that we are not equal partners. We feel they get more from us, we get less from them. And that is a problem. If we can negotiate in some way that we could be equal partners, so that they have something that we could learn, and of course we are willing to trade with them some science and engineering technology. We must have our academia, industry, and government work closely together to develop a unified strategy to work with them. But I must suggest that we have to proceed with caution, with a yellow light.

Senator BINGAMAN. What should we urge the Department of Defense do to establish continuing education programs to upgrade the engineers that we already have in the work force?

Dr. BOWEN. I think if we look at the way manufacturing or the practice of engineering is done, in some sense it is not reflective of all of the efforts in the research and discovery process over the last 30 years. So the first thing we need to do—let me suggest that the way, the relationship between the university and government agencies over the past 20 years has been much more a hands-off, supplier relationship. I give you this money, you give me reports. But the focus, and I think you have heard it from all three of us, really the mission of the university is to create people first and knowledge second. And what knowledge? The knowledge that should be taught should be the top of the agenda.

So we have been focusing on the papers, the invention, and in this process, the use of government funds, we have not focused on distilling that knowledge. So one of the major activities that I think should be done is an opportunity for true scholarship to take what we know and begin to put it in context and modules that are valuable for our universities, the research universities, also would be valuable for those 2-year colleges, and would be tremendously valuable for the million manufacturing engineers that are out there that do not have the current knowledge. So a tremendous effort on the materials so that people can be educated.

Senator BINGAMAN. Are you saying that we do not have good instructional materials on up-to-date manufacturing processes and knowledge?

Dr. BOWEN. Yes, and in the form that it needs to be to be accessible to the people in the plants and accessible in these 2-year colleges. We focus——

Senator BINGAMAN. What does government, what does this committee, what does the Department of Defense do if we were to direct them to resolve this problem? The committee received testimony from Will Willoughby of the Navy, regarding a program he developed, with the help of Bell Laboratories, a series of templates in best practices in manufacturing and design work. They do not have enough money to make many copies of those and distribute them. If what you are saying is right, that is a need that we should be able to correct without a dramatic or an exorbitant expenditure of funds.

Dr. BOWEN. If it were easy we would be doing it. It is complex. We are talking about the integrating of many disciplines to really understand how to conceive a product and produce and distribute products in a competitive way. This is not an easy intellectual problem that we are talking about. And second, the think time to do that is not available in the way the universities are currently structured.

I think we all indicated that as we got started at our universities to give more emphasis to this new discipline of manufacturing, a lot of the resources came from the firms, from American companies first, because the intellectual—it does not fit nicely into a narrow discipline funded by one of the agencies. And so for us to get started we have had to have visionaries from industry to provide those resources. But in all cases what the industrial sector is asking for is the education of people, what is the new knowledge they need to have, and now in what form is it available so that other people can be trained and educated.

Senator **Bingaman**. Thank you. As other questions arise while we try to develop legislation in this area, we will certainly contact you. Sam, I am about through with my questions. Did you have some questions?

Chairman **Nunn**. No, I do not.

Senator **Bingaman**. Let me indicate both Senator Nunn and I have taken an interest in trying to identify what we could do through the Department of Defense to assist in this area of manufacturing and engineering education. In addition, we would welcome your input as we go forward this year so that whatever we do is constructive. I believe we can make progress in this area, because I agree with all of you that it is an area that we have given too little attention. We are just now beginning to recognize our enormous shortfall in this area.

We held a hearing on May 7 regarding the 1991 Defense Critical Technologies Plan, in which the Japanese were listed as lagging us significantly in flexible manufacturing. Now that is not consistent with the information I have received. I would be interested in any comments any of the three of you have on that. My sense is that we are struggling to maintain parity with the Japanese in this whole area of flexible manufacturing. They have given tremendously greater emphasis and resources to it than we have over the years, and we need to get in gear if we are going to stay in the ball game. Do any of you want to comment on that comparison issue?

Dr. **Thomas**. I think there are some U.S. firms that are doing very well, but I think across the whole industrial complex we are not as, I am not as optimistic as the Defense Department testimony apparently indicated to you. There is also a report which I shared with one of your staffers about the Japanese plan for 21st century manufacturing, and their goals are to set up small factories close to suppliers and to consumers that are very flexible and will allow them to make lots of different things in the same sort of generic product line. Very close to the consumer, and so, for example, you would walk into an automobile store and order your automobile and they would have it for you the next day.

Dr. **Bowen**. I think we under appreciate the profound effect that their use often of our knowledge and their own knowledge has had. They have totally rewritten the mass production paradigm, this recent study from the group at M.I.T., the machine that changed the world. It is a whole new world, and we are barely catching on to what they did. So that is for mass production.

But for small volume production they again in sector after sector are figuring out how to do it, often with the kind of technology invented here. And I think again the message from the three of us is it is that integration, that is where we have not been putting our resources, and that is what we are asking you to consider, the new way to look at the integrated enterprise, the more integrated economy, the supplier and user systems.

Senator **Bingaman**. I gather we have got about 370,000 manufacturing type businesses in this country of 500 or fewer employees. Unfortunately, these businesses are not participating in your program at M.I.T. and probably not in the programs at the other two universities to a great extent either. So they do not receive this information.

Dean Yang, did you have any other comment before we adjourn this hearing?

Dr. YANG. I think, Senator, you are very perceptive about this issue. What you just said I totally agree. I think the Japanese are very good at integrating all segments, all industry, and all disciplines together in a cross-disciplinary fashion, and we have to do more in order to compete.

Senator BINGAMAN. We appreciate your testimony very much and I believe it has been a very useful hearing.

[Whereupon, at 11:45 a.m., the subcommittee was adjourned.]

DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEARS 1992 AND 1993

TUESDAY, MAY 21, 1991

U.S. Senate,
Subcommittee on Defense Industry and Technology,
Committee on Armed Services,
Washington, DC.

DEPARTMENT OF DEFENSE IN-HOUSE LABORATORY SYSTEM

The subcommittee met, pursuant to notice, at 9:40 a.m., in room SD-562, Dirksen Senate Office Building, Senator Jeff Bingaman (chairman of the subcommittee) presiding.

Committee members present: Senators Bingaman and Coats.

Committee staff member present: Andrew S. Effron, general counsel.

Professional staff member present: William H. Smith.

Minority staff members present: Romie L. Brownlee, deputy staff director for the minority; Jonathan L. Etherton and Mark B. Robinson, professional staff members.

Staff assistant present: Debra A. Rice.

Committee members' assistants present: John P. Gerhart, assistant to Senator Bingaman; Melvin G. Dubee, assistant to Senator Byrd; Eric H. Thoemmes, assistant to Senator Coats; and Thomas L. Lankford, assistant to Senator Smith.

OPENING STATEMENT OF SENATOR JEFF BINGAMAN, CHAIRMAN

Senator Bingaman. The subcommittee will come to order.

The Department of Defense in-house laboratories have played an important part in development, deployment and support of many of our Nation's most effective weapons systems. They also continue to play an important role in maintaining our advantage in all of the technologies that contribute to the superiority of the weapons systems. It was this technological advantage that was so convincingly demonstrated in project Desert Storm. And, as the technological advantages of the defense and nondefense sector continue to converge and to overlap, I believe these laboratories, along with the Department of Energy's national laboratories, will play an ever-increasing role in providing the innovations and the inventions that will support both our national security and its economic growth.

The dramatic changes that have occurred in America's national security environment, from the fall of the Berlin Wall and the dissolution of the Warsaw Pact to our stunning success in the Persian Gulf, have collectively impacted the policy and direction of the United States' defense structure in a very fundamental way. The impact will be felt across the entire defense industrial base and it will be felt in the defense in-house laboratories. Just as it is critical that we find a way to maintain a robust and flexible defense industrial base during these times of change, it is equally important that we find a way to maintain these Defense laboratories so that they can continue to respond to a broad range of military contingencies that may arise in the future.

The Senate Armed Services Committee has taken two recent actions intended to improve the effectiveness and flexibility of Defense laboratories. In our report accompanying the National Defense Authorization Act for 1990 and 1991, the committee directed the Defense Department to establish a Laboratory Demonstration Program aimed at improving the management and operations at the Defense laboratories. It focused on four major concerns: (1) attracting and retaining top quality people; (2) modernizing research facilities and equipment; (3) simplifying R&D contracting procedures; and (4) giving the lab directors greater management authority.

The second action taken by our committee was to include a provision in last year's Defense Authorization Act to establish a Commission on the Consolidation and Conversion of Defense R&D Laboratories. This Commission, headed by the Director, Defense Research and Engineering, is intended to review the health and effectiveness of the Defense laboratories and to make recommendations to the Secretary of Defense and to the Congress on organizational and structural changes that would improve those laboratories. I understand the Commission has just begun its work.

On April 12 of this year, Secretary Cheney released the Defense Department's recommendations on base closings to the Base Closure Commission. Included on that list were recommendations affecting several Army and Navy laboratories. One question that subsequently has been raised is concerning the relationship that exists between the Base Closure Commission and the laboratory Commission. I would note that, in law, there is no direct relationship. Both groups do, however, address similar issues and concerns. The advice of the laboratory Commission could well be useful to the Base Closure Commission if it were available on a timely basis.

On March 22 of this year, a letter signed by 62 Members of Congress was sent to Secretary Cheney that recommended that no decision to close any defense lab should be made until the laboratory Commission had completed its work. This morning, Senator Inouye, Chairman of the Defense Appropriations Subcommittee, is making a similar recommendation in his statement to the Base Closure Commission. I am not aware of any response that the Department has made to the earlier letter, but I understand that the Base Closure Commission is proceeding to review the Department's list that includes laboratories and R&D centers.

We have asked the acting DDR&E, Mr. Charles Adolph, to join us today, and give us his insight on how the Department intends to use the work of the laboratory Commission to improve the operations of the laboratories and how the work of the lab Commission might be used to support the Base Closure Commission. We have also asked Mr. Adolph to update the subcommittee on the progress being made on the Laboratory Demonstration Program.

Joining Mr. Adolph on the panel will be representatives of the three services, Dr. George Singley from the Army; Mrs. Genie McBurnett from the Navy; and Brigadier General Stephen Condon from the Air Force. We have asked each of these witnesses to testify on the methodology and the evaluation criteria that have been used in making decisions on realignments and consolidations or closures of laboratories under their service's command. We would also appreciate hearing from each on how the Laboratory Demonstration Program is progressing within their service. We thank each of you for joining the subcommittee this morning and look forward to your testimony.

Before we proceed, let me defer to the ranking member, Senator Coats, for any statement that he would like to make.

Senator COATS. Mr. Chairman, I have a brief opening statement which I will ask unanimous consent to have made part of the record.

I look forward to the testimony of the witnesses this morning on the subject that ends up being near and dear to all of our hearts, depending on where these labs are.

I think there is growing consensus on the part of Congress that we cannot have it both ways. We cannot ask for an efficient, effective Department of Defense and then deny for political reasons conclusions, decisions that you make relative to how you perform your mission with the most efficiency and the most cost-effectiveness.

As I have stated relative to the base closing procedure, as long as you follow the criteria established in the legislation and make objective determinations, we want to do everything we can.

We ought to do everything we can to support that in the name of providing the most efficiency, the best quality product that we possibly can.

So I look forward to your testimony this morning in terms of your recommendations and also in terms of how you feel this should coordinate with the Base Closing Commission procedure.

So with that, we will look forward to the testimony of the witnesses.

[The prepared statement of Senator Coats follows:]

PREPARED STATEMENT BY SENATOR DAN COATS

Mr. Chairman, it is appropriate that we should hold this hearing to review how OSD and the services are complying with the Base Closure Commission along with legislation regarding the Laboratory Commission Study initiated by this subcommittee last year in the Defense authorization bill.

It has been our hope that we could eliminate inefficient and unneeded labs and consolidate others in order to achieve the most efficient and effective laboratory system for our defense needs.

In addition, the Lab Demonstration Program, which was initiated by this subcommittee 2 years ago, was intended to improve the overall quality of the DOD laboratory system.

I look forward to hearing testimony today from our witnesses on the impact of this legislation on the total effectiveness of the laboratory system.

Senator BINGAMAN. Mr. Adolph, why do you not begin, and then we will hear from the other witnesses before we ask questions.

STATEMENT OF CHARLES E. ADOLPH, ACTING DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE, ACCOMPANIED BY RAY SIEWERT, ACTING DEPUTY DIRECTOR, DEFENSE RESEARCH AND ENGINEERING FOR RESEARCH AND ADVANCED TECHNOLOGY

Mr. ADOLPH. Mr. Chairman and members of the committee, ladies and gentlemen, I am Pete Adolph, and I have been designated by the Secretary of Defense to perform the duties of the Director of Defense Research and Engineering until a director is appointed.

My written statement has been submitted for the record, and with your permission I will restrict my opening remarks.

Senator BINGAMAN. That is fine, and if each of you will summarize your statement, we will include the full statement in the record. Thank you.

Mr. ADOLPH. With me is Ray Siewert, Acting Deputy Director of Defense Research and Engineering for Research and Advanced Technology, and as you mentioned, Mr. Chairman, my service colleagues are here, and I am pleased to be with them to testify on our current initiatives to strengthen the technology base, to streamline the management of the Department laboratories, and to reduce the costs of doing business.

Much of the work we are doing falls under the aegis of the Defense Management Review which requires us to seek ways in which the DOD can perform its mission more efficiently, and we are making steady progress, and I am pleased by the high degree of coordination and cooperation between the Office of the Secretary of Defense and the services in working these initiatives, and we are here today to report on that progress.

Our strategy for defense technology includes taking the management actions necessary to maintain our qualitative superiority and deterrence and warfighting capabilities. We do have a continuing need for an integrated, stable, and strong research, development, test, and evaluation program, one that links technological leadership to military requirements, and a critically important ingredient is the DOD in-house laboratory system.

In response to a requirement for a more unified approach to management of RDT&E, the Director of Defense, Research and Engineering has established two steering groups, one for test and evaluation and one for science and technology which Ray Siewert chairs.

The laboratory system falls under the purview of the Science and Technology Steering Group, and this steering group oversees our major laboratory management initiatives, including laboratory restructuring, the Laboratory Demonstration Program, and Project Reliance. The service representatives of that group are here today.

I want to take a moment to describe the Tri-Service Reliance effort, because it exemplifies the teamwork I told you about earlier. Although Reliance addresses both science and technology and test and evaluation, I want to concentrate my remarks on the science and technology part.

Reliance is a major Defense Management Review effort being conducted by the services and OSD to enhance the effectiveness and productivity of our research, development, test and evaluation infrastructure by first eliminating unwarranted duplication, second, connecting related technology efforts, and finally, refocusing future investments to strengthen and modernize our facilities, and all the while preserving the services' unique mission-essential capabilities.

The intent is to build on the strengths inherent in each service's system for the benefit of everyone and to foster interdepartmental reliance when that makes sense.

I want to emphasize that the breadth and depth of the Reliance effort is really unprecedented in the history of the Department. We have thoroughly reviewed our laboratories, identified 28 technology areas, and assigned each to one of the following categories: programs that are unique to a given service, coordinated programs, joint efforts, co-location, consolidation, and competition.

Having done this, we are now reorganizing away from coordination, which is the weakest and least productive alternative, and toward the other options. The Director of Defense Research and Engineering reviews all Reliance strategy and implementation plans and makes recommendations to the Under Secretary of Defense for Acquisition. The service representatives who spearheaded this tremendous effort will address the specifics in a moment.

The Defense Technology and Test Action Plan, which defines the actions necessary to implement DMR 922, will be signed out in the near future by the Deputy Secretary of Defense. It includes actions and milestones for investment planning, for workload measurements, and for implementation of Project Reliance decisions.

Consolidation, conversion, and realignment of the Defense laboratory system has been the subject of intense study since the summer of 1989, when the Deputy Secretary of Defense established the DMR Laboratory Consolidation Working Group. This OSD and Tri-Service working group studied various management alternatives in addition to closures, consolidations, and realignments.

These studies were in the final stages when Congress directed the Secretary to establish a Commission on Laboratory Consolidation and Conversion to review the health and effectiveness of the labs, using the DMR studies as a starting point, and to make recommendations on the means to improve the operation of the laboratories.

The Federal Advisory Commission, as you indicated, Mr. Chairman, has initiated its review. They have held their first two meetings, which consisted primarily of information-gathering and policy sessions. The Commission has been briefed in detail by the services on their consolidation plans, on Project Reliance, by the Base Closure Office they have been briefed on the Laboratory Demonstration Program, and they have interviewed staff on the House Armed Services Committee and the Congressional Research Service to make sure that they are faithfully responding to the intent of Congress.

In addition, the Commission has invited one of your staff members to meet with them later this week, and the Commission will meet the mandated September 30, 1991 reporting date to the Secretary of Defense.

Senator **Bingaman**. What date is that?

Mr. **Adolph**. September 30, and the Commission will meet that date. That is a report to the Secretary.

Let me turn now to the Laboratory Demonstration Program. I think that the laboratory system has an enviable record of technological accomplishments. Nevertheless, there are some bureaucratic impediments which have hampered the laboratories' ability to compete in the labor market for high caliber scientists and engineers. In addition, the effectiveness of research efforts has been reduced because of inadequate facilities and equipment.

In November 1989, the Deputy Secretary of Defense initiated the Laboratory Demonstration Program and the Department has taken a 5-level approach, first implementing changes at the laboratory level, second implementing changes within the purview of the services and defense agencies, third, implementing changes that are within the authority of DOD, fourth, negotiating with other government agencies such as the Office of Personnel Management to secure increased authority within existing law, and finally, when no other recourse is available, seeking legislative changes.

I would like to highlight some of the initiatives and briefly outline some of the accomplishments to date. Our personnel management initiatives seek direct hiring authority, implementation of special salary and pay-banning schedules, and the delegation of increased personnel authority to base commanders.

Some accomplishments to date include—and these have occurred over the past year—first, the Office of Personnel Management delegated increased local hiring authority to DOD in June 1990, and we have been able to hire 59 new Ph.D's since then. OPM has also authorized 27 additional science and technology positions, and I understand they have since added another 10 to that, and I think that is really significant in today's downsizing environment.

Next, contracting and procurement initiatives have been put in place to reduce time-consuming procurement methods and contracting for R&D supplies and services to increase the small purchase threshold to accommodate one-of-a-kind R&D purchases, and to increase the small purchase competition threshold. There is a seemingly innocuous measure, the delegated use of VISA credit cards to S&E's for small purchases, which has cut down the lead time for those types of purchases from an average of 100 to 6 days.

Major facilities modernization initiatives will increase the effectiveness of the laboratory infrastructure, and we want to give the laboratory directors the ability to use scarce resources efficiently and establish a process to create modern facilities suitable for the conduct of state-of-the art R&D.

Our management authority initiatives seek delegation of increased authority to the laboratory directors to control essential support activities in a manner similar to that practice under the profit-center concept of the private sector. I want to have longer tenure for laboratory directors, fewer reporting levels, and discretionary R&D funding for laboratory directors.

I think the accomplishments to date are noteworthy, and I will cite one for each of the services to illustrate the point.

The Navy has delegated contracting authority for an unlimited amount to its laboratory directors. The Army's Laboratory Command has provided its laboratory directors with increased direct control over critical administrative support services, and Air Force labs have cut their average procurement lead time in half for some types of equipment and services. The Defense Nuclear Agency has provided increased management authority to its laboratory director.

A draft legislative proposal, the DOD Revitalization Demonstration Act of 1991 has been prepared, and is in formal coordination in the Department. This will request legislative authority to demonstrate new and innovative approaches to managing and operating DOD laboratories.

In summary, the Department has made a determined effort to strengthen its management of the laboratory system through an integrated corporate approach that provides policy direction and continuity from the Director of Defense Research and Engineering and the Science and Technology Steering Group.

We are making real progress in addressing the complex and abiding problems that hamper the laboratory system. The result will be a more efficient and effective laboratory system, one that allows this Nation to maintain and strengthen the technological edge that has been and will remain a vital part of our national security strategy.

[The prepared statement of Mr. Adolph follows:]

PREPARED STATEMENT BY CHARLES E. ADOLPH

Mr. Chairman, members of the committee, ladies and gentlemen. I am Pete Adolph. I have been designated by the Secretary of Defense to perform the duties of the Director, Defense Research and Engineering (DDR&E), until a Director is appointed. With me is Ray Siewert, Acting Deputy Director, Defense Research and Engineering, for Research and Advanced Technology. Also testifying this morning are George Singley, Deputy Assistant Secretary of the Army for Research and Technology; Genie McBurnett, Principal Deputy Assistant Secretary of the Navy for Research, Development, and Acquisition; and Brig. Gen. Pat Condon, Deputy Assistant Secretary of the Air Force for Management Policy and Program Integration. He is here today in his capacity as Acting Director of Science and Technology for the Air Force. I'm pleased to be here with my colleagues to testify on our current initiatives to strengthen the technology base, to streamline the management of the Department of Defense (DOD) laboratories, and to reduce the cost of conducting business.

Much of the work we are doing falls under the aegis of the Defense Management Review (DMR), which requires us to seek ways in which the Department of Defense can perform its vital national security mission more efficiently. We are making steady progress. I am pleased by the high level of coordination and cooperation between the Office of the Secretary of Defense (OSD) and the services in working these initiatives. We are here together today to report on our progress and continue our dialogue with you.

As evidenced by the success of Desert Storm, the Department has been correct in basing its strategy for national defense on developing superior technology. We will continue our commitment to provide our soldiers, sailors, airmen, and marines with superior technology as our national security policy adapts to the dramatic changes taking place in the world. Our strategy for defense technology includes fostering those conditions essential to maintaining our qualitative superiority in deterrence and warfighting capabilities. As a result, we have a heightened need for a coherent, integrated, stable, and strong research, development, test, and evaluation (RDT&E) program; one that links technological leadership to military needs. A critically important ingredient is the DOD in-house laboratory system.

In response to the requirement for a more corporate, unified approach to management of RDT&E, the DDR&E has established two steering groups, one for test and evaluation (T&E), which I chair, and one for science and technology (S&T), which Ray Siewert chairs. These two steering groups will be able to advise the DDR&E in a more cohesive manner on resource and policy matters.

The laboratory system falls under the purview of the S&T Steering Group, which will advise the DDR&E on integrating service and Defense Agency technology objectives, infrastructure problems, and investment strategies. I mention this steering group this morning because, on behalf of the DDR&E, it will oversee our major laboratory management initiatives, including laboratory restructuring, the Laboratory Demonstration Program, and Project Reliance.

I want to take a moment to describe the Tri-Service Reliance effort because it exemplifies the teamwork I talked about earlier. Although Reliance focuses on both S&T and T&E, I will concentrate my remarks on the S&T portion.

Reliance is a major DMR effort being conducted by the services and OSD to enhance the effectiveness and productivity of our facility investments and in-house work, eliminate unwarranted duplication and unnecessary overlap, connect related technology efforts, and refocus investments to strengthen and modernize our facilities—all the while preserving the services' unique, mission-essential capabilities. The intent is to build on the strengths inherent in each service's system for the benefit of everyone and to foster inter-departmental reliance when that makes sense. We have thoroughly reviewed our laboratories and identified various programs, first by assigning them to 28 technology areas and then to several operational categories: programs unique to one service, coordinated programs, joint efforts, collocation, consolidation, and competition. Having done this, we are now reorganizing away from coordination—the weakest and least productive alternative—and toward the other options. The DDR&E reviews all Reliance strategy and implementation plans and makes recommendations to the Under Secretary of Defense for Acquisition. I will not elaborate further on Reliance since the service representatives who spearheaded this tremendous and productive effort are here with me and will address specifics in their presentations.

The Defense Technology and Test Action Plan, which presents the specific actions and milestones necessary for the RDT&E community to effect the cost reductions and increases in efficiency directed by DMR 922, will be signed out soon by the Deputy Secretary of Defense. It includes actions and milestones for investment planning, for workload measures, and for implementation of Project Reliance decisions.

Consolidation, conversion, and realignment of the Defense laboratory system have been the subject of intense study in the Department and the services since the summer of 1989. Stimulated by the recommendations of the 1988 Report of the Secretary's Commission on Base Realignment and Closure, the Secretary's Defense Management Review, and other reports such as those from the Office of Technology Assessment, the Department conducted expansive and systematic studies of the near- and long-term savings that we could achieve through consolidations and closure of Defense laboratories. The Deputy Secretary of Defense established the DMR Laboratory Consolidation Working Group in the fall of 1989 to develop recommendations. This OSD/Tri-Service working group studied management alternatives such as government-owned/contractor-operated facilities (GOCO's), employee-owned contractor operations, government corporations, and hybrids of various options in addition to closures, consolidations, and realignments. These studies were in the final stages when, in Senate Report 101-384 on the National Defense Authorization Act for Fiscal Year 1991, Congress directed the Secretary to establish a Commission on Laboratory Consolidation and Conversion with the charter to review the health and effectiveness of defense laboratories, using DMR studies as a starting point, and to make recommendations on the means to improve the operation of these laboratories.

This Federal Advisory Commission has initiated its review of ways to improve the operations of the laboratories.

In selecting the Commission members, the Secretary chose three DOD laboratory directors who had played an active role in the DMR studies, the Director of DARPA, executives from the Department of Energy and the National Institute of Standards and Technology, the vice presidents for research at Bell Labs and IBM, the director of Los Alamos Laboratory, and other equally qualified scientists and engineers. These individuals have brought an outstanding breadth of expertise and experience to review the services' laboratory consolidation plans and other means of improving the operations of the Defense laboratories.

The Commission's first two meetings consisted primarily of information gathering and policy discussions. This is an important process. They have been briefed in detail by the services on their consolidation plans and on Project Reliance. The base closure office in OSD has briefed the Commission on the Secretary's proposal to the Base Closure and Realignment Commission. They were briefed on the Laboratory Demonstration Program, and they have interviewed staff from the House Armed Services Committee and the Congressional Research Service to make sure they are accurately responding to the intent of Congress. Additionally, the Commission has invited a staff member of the Senate Armed Services Committee to meet with them later this week. The Commission members have a well-defined meeting schedule, are addressing their duties systematically, and fully expect to meet the mandated September 30, 1991, reporting date to the Secretary of Defense.

Let me turn now to the Laboratory Demonstration Program. The Department of Defense laboratory system has an enviable record of technological accomplishments. Nevertheless, for too long bureaucratic impediments have hampered the Defense laboratories' ability to compete in the labor market for high-caliber scientists and engineers. The effectiveness of their research efforts has been reduced because of inadequate facilities and equipment and other management inefficiencies.

I want to briefly review some of what has transpired in the last 2 years. Through Senate Report 101-81 on the National Defense Authorization Act for Fiscal Years 1990 and 1991, Congress endorsed recommendations of the 1987 Defense Science Board study and directed the Department to implement a Laboratory Demonstration Program.

On November 20, 1989, Deputy Secretary of Defense Donald J. Atwood initiated this program. In his authorizing letter he stated, "Recent studies conducted by the Defense Science Board and validated by the DDR&E Interagency Task Force have shown that the productivity and effectiveness of DOD laboratories can be significantly improved by implementing specific changes in procedures involving personnel management, research related contracting, facilities refurbishment, and management authority of technical directors."

The Department has taken a five-level approach for (1) implementing changes at the laboratory level; (2) implementing changes that are within the authority of the services and Defense Agencies; (3) implementing changes that are within the authority of DOD; (4) negotiating with other government agencies (e.g., the Office of Personnel Management) to secure increased authority within existing law; and (5) when no other recourse is available, seeking legislative changes.

Participation in the DMR Laboratory Demonstration Program was granted to those Defense laboratories nominated by the services and the Defense Nuclear Agency and approved by the Under Secretary of Defense for Acquisition. Collectively, and prior to recently proposed restructuring plans, the Demonstration Laboratories employed approximately a quarter of DOD scientists and engineers (S&E's), including approximately 21 percent of Army S&E's, 31 percent of Navy S&E's, and 12 percent of Air Force S&E's. These laboratories represent a broad spectrum of the mission areas, science and technology strengths, laboratory sizes, workforce profiles, R&D programs, and financial and management arrangements that characterize the DOD laboratory system as a whole. As a group, they represent an effective cross-section of essential in-house laboratory capability.

I would like to highlight some of our principal areas of concern and briefly illustrate some of our accomplishments.

Our *personnel management initiatives* seek acquisition of direct hiring authority for all positions; acquisition, development, and retention of S&T positions; implementation of special salary and pay-banding schedules; delegation of increased personnel authority to base commanders; recruitment and retention bonuses; and non-career appointments for retired distinguished senior experts. Some accomplishments to date include: The Office of Personnel Management (OPM) delegated increased local hiring authority to DOD in June 1990. We have been able to hire 59 new PhD's since then. OPM has also authorized 27 additional science and technology positions; and automated classification systems are operating at selected installations. These and other contemplated actions will help the Department develop a personnel climate that will restore our competitiveness in recruiting and retaining the most talented S&E's.

Contracting and procurement initiatives have been put in place to reduce complex and time-consuming procurement methods in contracting for R&D supplies and services; to increase the small purchase threshold to accommodate unique, one-of-a-kind R&D purchases; and to increase the small purchase competition threshold to significantly reduce procurement acquisition lead times. A seemingly innocuous measure, the delegated use of VISA credit cards to S&E's for small purchases, reduced the average lead time from 100 days to 6 days while ensuring adequate management control. We believe these measures, together with other proposed measures, will give us streamlined procurement procedures that will eliminate excessive and burdensome management controls of the past.

Major *facilities modernization initiatives* will increase the effectiveness of resources targeted at improving the laboratory infrastructure. We want to give laboratory directors the ability to use scarce resources efficiently and establish a process to create and sustain modern facilities suitable for the conduct of state-of-the-art research and development.

Management authority initiatives seek delegation of increased authority to laboratory directors to control essential support activities in a manner similar to that practiced under the separate-profit-center concept of the private sector; longer tenure for laboratory directors; fewer reporting levels; increased contracting authority for laboratory directors covering services, products, and facilities; and discretionary R&D funding for laboratory directors for enhanced in-house independent research and exploratory development with after-the-fact annual performance reviews. Accomplishments to date are noteworthy: The Navy has delegated contracting authority for an unlimited amount to its laboratory directors; the Army's Laboratory Command has provided its laboratory directors with increased direct control over critical administrative support services; Air Force laboratories have cut the average acquisition lead time in half for some types of equipment and services; and the Defense Nuclear Agency has provided increased management authority to its laboratory director in contracting and technical publications. These measures are designed to vest Defense laboratory directors with levels of authority commensurate with their responsibilities.

A draft legislative proposal, the *DOD Laboratory Revitalization Demonstration Act of 1991*, has been prepared and is undergoing formal coordination within the Department. This will request legislative authority to demonstrate new and innovative approaches to managing and operating DOD laboratories. The ideas that improve laboratory operations will be exported to other DOD laboratories that are not a part of the demonstration.

As a final note on laboratory demonstration, I would like to address the criteria we are using to evaluate various reforms. In his letter of November 20, 1989, the Deputy Secretary tasked the services and Defense Nuclear Agency to identify those parameters that are especially important to their particular operations and missions that could be used as "measures of success." The selected indicators were reviewed and refined by the OSD Laboratory Demonstration Program Working Group and will be used to track the progress of the services and Defense Nuclear Agency. However, I need to caution that using such indicators as "measures" may not always reflect the actual health or improvement in any one laboratory or in the aggregate of demonstration laboratories. The current measures are only a start; we will refine them as needed.

In summary, we have made a determined effort to strengthen our management of the Department's laboratory system through an integrated, corporate approach that provides policy direction and continuity from the DDR&E and the S&T steering group. The DDR&E is also ensuring that the many initiatives we have undertaken are coordinated toward a common purpose. I anticipate that we will see an increasing amount of inter-service collaboration, both in our efforts to organize and operate the laboratory system more efficiently and in the day-to-day conduct of laboratory work. Because of DMR 922 and the many in-house efforts it has initiated, the development of proposals for base realignment and closure, the guidance we expect from the Advisory Commission, and the many and varied successes and proposals of the Laboratory Demonstration Program, we are making real progress in addressing the complex and abiding problems that hamper the laboratory system today. The result will be a more efficient and effective laboratory system, one that allows this Nation to maintain and strengthen the technological edge that has been—and will remain—a vital part of our national security strategy.

Senator BINGAMAN. Thank you very much. We will now proceed with the other witnesses before we ask questions. Mr. Singley please go ahead.

STATEMENT OF GEORGE T. SINGLEY III, DEPUTY ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY, DEPARTMENT OF THE ARMY

Mr. SINGLEY. Thank you, sir.

Mr. Chairman, members of the committee, it is indeed a pleasure to appear before this committee and discuss the Army's initiatives for improving the quality and productivity of our in-house laboratories.

In President Bush's 1991 State of the Union Address, he spoke of the remarkable military technological achievements being successfully employed in Operation Desert Storm. He said, "The quality of American technology, thanks to the American worker, has enabled us to successfully deal with the difficult military conditions and help minimize precious loss of life. We have given our men and women the very best, and they deserve it."

The primary goal of the Army Technology Base is to continue to provide our future military forces with the very best, because today's soldier benefits from the world's best technology, and tomorrow's soldier deserves no less.

A large portion of the high technology tools employed so successfully by our forces in Operation Desert Storm benefited from the Army's technology base investment of the past two decades. For example, night vision technology let us own the night and save many soldiers' lives.

The Army's "Big 5" weapons systems, started nearly two decades ago, proved themselves. They are the Apache and Black Hawk helicopters, the Abrams tank, the Patriot missile system, and the Bradley Fighting Vehicle System.

Operation Desert Storm demonstrated that certain weapon system capabilities are essential for success with minimum friendly losses on the modern battlefield. They include stealth, anti-tactical ballistic missiles, smart weapons/munitions, air mobility, chemical and biological detection and protection, countermine, AirLand battle management, and exploitation of space.

To satisfy the needs of our future forces, the Army Technology Base Master Plan is being followed. The plan states the Army's vision, strategy, and our road map to the future. This plan was approved by the Secretary of the Army and the Chief of Staff of the Army. It was provided to government, industry, and academia in November 1990. It is a resource constrained, Headquarters Department of the Army guidance to the Army and industry. The document delineates Army priorities and details approximately 200 funded science and technology objectives, many of which will support the future systems and system upgrades identified in the Army's modernization plans as well as the Defense Critical Technologies Plan.

The role of our laboratories and centers has undergone a significant change from the 1940s and the 1950s. Continued process and organizational improvements are even more important today as we face a declining Defense budget, reduced force structure, and the world-wide proliferation of high technology conventional arms. Correspondingly, the Army has undertaken a number of management initiatives to make the Army's 21st century research and development efforts more efficient and effective. I would like to briefly discuss three of these with you today.

I will discuss our Laboratory 21 initiative, the Tri-Service Project Reliance effort, and the Laboratory Demonstration Program and the Army's role therein.

The Army's Lab 21 program is included under our Base Closure and Realignment Act of 1990 submission. This 6-year program is designed to improve the quality, productivity, and efficiency of Army research and development organizations, while increasing their ability to attract and retain high quality scientists and engineers.

Our organizational design for the laboratories was driven by our modernization vision, strategy, and action plan as documented in the Technology Base Master Plan. Extensive analyses and numerous alternatives were conducted, using a uniform set of evaluation factors and attributes.

The Lab 21 factors used were consistent with and complementary of those used for the 1991 base realignment and closure analyses, and represent those considerations which are critical to increased productivity and quality products and services.

One of the key elements of the Lab 21 is a creation of a world class flagship laboratory called, the Combat Materiel Research Laboratory (CMRL). If approved, the CMRL will be headquartered at Adelphi, Maryland, home for the following directorates: a signature, sensors, and signal processing directorate, one in battlefield and environmental effects, another in electronics and power sources, and one in directed energy.

Lethality, materials, life sciences; and simulation, modeling, and assessment directorates of CMRL would be located at the Aberdeen Proving Ground, Maryland where extensive test and range capabilities already exist.

Our second major initiative has to do with the Tri-Service Project Reliance Study. A number of Army medical research and labs would be reduced under this proposal, from nine to six, while seven tri-service medical programs would be collocated at single service sites. Realigning medical research laboratories and programs achieves efficiencies through inter-department consolidations, transfers, and reliance on technology.

The third point I would like to make is that the Army is participating extensively in the Defense Laboratory Demonstration Program. Army demonstration laboratories and centers are: all seven Army Laboratory Command corporate laboratories, the AMC Missile Research, Development and Engineering Center in Huntsville, Alabama, the Corps of Engineers' Waterways Experimental Station in Vicksburg, Mississippi, and all laboratories of the Surgeon Generals' Medical Research Development Command.

Army initiatives fall under the following categories and reflect the underlying philosophy of the Office of Technology Assessment's report entitled, "Holding the Edge."

In the area of management authority, we have transferred support organizations to the operational control of the laboratory and center directors. While specific implementation varies from organization to organization and function to function, in all cases, the ability of the corporate leadership to execute its R&D mission has been strengthened.

Second, at two of the three organizations which have civilian directors, each have been appointed for a minimum of 4 years with subsequent renewal possible, if deemed desirable. The other laboratory deemed this action unnecessary as the average tenure of the past two directors has been 30 years. The nine medical R&D command labs have military directors and commanders, but will institutionalize a 4-year tenure beginning in August of this year.

In the area of personnel, we have extended the career track for world class scientists and engineers to the Scientific and Technical Corps, which is equivalent to a GS–16 through GS–18 in pay. This year, 22 additional science and technical positions were approved by the Office of Personnel Management, bringing the Army's authorized S&T strength to 29. Twelve of these 29 S&T positions are in the Army's demonstration laboratories.

And I would like to stress, sir, that I think this is one of the most significant things that we have been able to do for our people in the scientific and technical area, because it truly gives us a dual track, wherein, an individual does not have to shift into the SES field to reach the highest levels of government. He can achieve a super grade level on a true dual track path. So, this is really giving credibility to the dual track initiative.

We are participating in the testing of automated personnel documentation systems as part of the effort to delegate personnel classification authority to managers.

We have obtained authority to direct hire our Ph.D's for the GS–9/11/12-hire levels, for all demonstration laboratories. Since July 1990, the demonstration laboratories have appointed 16 Ph.D's, using this direct-hire authority. This accelerates the recruiting process by 3 to 5 months.

And if I might add a personal note to this, when I headed one of the divisions in the career ladder to my current position, I found this to be a very large problem. We had folks that were just coming out of first quality, highest quality graduate schools with Ph.D's. And we just simply could not compete with industry or with academia, because we had to offer them such a low salary. I think this is another significant initiative that the Laboratory Demonstration Program has done for us.

In the area of contracting, we have authorized demonstration laboratory and center directors to use alternatives to the Army supply system for small purchases. That is those that are under $25,000. Using this discretionary authority, we have seen significant improvement in the timeliness and efficiency of small purchases. We have seen specific examples where the waiting time for requests to the receipt of equipment has dropped from 100 days to a week or less.

Scientists and engineers at nine of our demonstration laboratories have been given limited ordering authority for small purchases, that is those under $2,500. This has been achieved through the use of a government-wide commercial credit card service. Our test sites using this card report great success and satisfaction with this initiative. Critical supplies and materials are often obtained in 1 to 2 days, thus, reducing down time on priority technology projects. The Director of Harry Diamond Laboratories, Jerry Reed, who is here with me today, estimates that this has saved approximately $3.6 to $5 million per year in engineer and scientist down time alone for fiscal years 1989 and 1990.

We have encouraged the maximum use of grants, broad agency announcements, and small business innovative research contracts which take one third the time of the normal contract action process.

In the area of facilities and equipment, we have strengthened the authority to purchase scientific equipment, computational systems, and laboratory special purpose equipment. All of the AMC laboratories and the Waterways Experimental Station are now using a laboratory overhead account to purchase modern equipment.

In summary, Mr. Chairman, the Army is responding to the worldwide political, economic, and technological challenge by making fundamental organizational and management improvements. The cumulative effect of these actions is a major institutional change to enhance productivity and quality. Maintaining a strong Army technology base in the face of declining budgets is, indeed, a real challenge. But the initiatives and proposals, and the support that we received from the Congress, I believe are designed to meet this challenge head on.

Mr. Chairman, thank you again for this opportunity to appear before your committee and I welcome the opportunity to answer any questions you may have.

[The prepared statement of Mr. Singley follows:]

PREPARED STATEMENT BY GEORGE T. SINGLEY III, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY

Mr. Chairman, members of the committee, it is indeed a pleasure to appear before this committee and discuss the Army's initiatives for improving the quality and productivity of our in-house laboratories.

In President Bush's 1991 State of the Union address in January, he spoke of the remarkable military technological advances being successfully employed in Operation Desert Storm. He said: "The quality of American technology, thanks to the American worker, has enabled us to successfully deal with difficult military conditions and help minimize precious loss of life. We have given our men and women the very best. And they deserve it." The primary goal of the Army Technology Base is to continue to provide our future military forces with the very best.

The Army's Technology Base is the genesis of a large portion of the high technology tools employed so successfully by our forces in Operation Desert Storm. For example, infrared and night vision technology let us own the night and saved many soldiers' lives. The Army's "Big 5" weapon systems started two decades ago proved themselves: the Apache and Blackhawk helicopters, Abrams tank, Patriot missile system, and Bradley Fighting Vehicle System. Operation Desert Storm demonstrated that certain weapon system capabilities are essential for success with minimum friendly losses on the modern day battlefield: stealth, anti-tactical ballistic missiles; smart weapons/munitions; air mobility; chemical/biological detection and protection; countermine; airland battle management; and exploration of space.

ARMY TECHNOLOGY BASE

- PLANNING →
  - ARMY TECHNOLOGY BASE MASTER PLAN (NOV 90 UPDATE)
    - PROVIDES VISION, STRATEGY & ROADMAP
- PROGRAM →
  - BALANCED USE OF SCARCE RESOURCES
  - FUNDING STABILITY FOR 6.1 AND 6.2
  - ATTD'S TO SPEED TECHNOLOGY MATURATION / TRANSITION - 21 APPROVED TO DATE
- MANAGEMENT →
  - LABORATORY 21/PROJECT RELIANCE
    - CONSOLIDATION TO IMPROVE EFFICIENCY/MAINTAIN CRITICAL MASS
- PRODUCTS →
  - EVOLUTIONARY & REVOLUTIONARY CAPABILITIES - TECHNOLOGY FOR SYSTEM UPGRADES
  - SUPPORT FOR OPERATION DESERT STORM

TODAY'S SOLDIER HAS WORLD'S BEST TECHNOLOGY ...
TOMORROW'S DESERVES NO LESS

To best respond to the needs of our future forces, the Army's Technology Base agenda incorporates major initiatives which serve as the foundation for a vigorous planning process, a responsive program, sound management and superior products. The planning process focuses on the continued implementation of the Army Technology Base Master Plan.

ARMY TECHNOLOGY BASE

- PLANNING → • ARMY TECHNOLOGY BASE MASTER PLAN (NOV 90 UPDATE)
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TODAY'S SOLDIER HAS WORLD'S BEST TECHNOLOGY ...
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This plan was approved by the Secretary of the Army and the Chief of Staff of the Army and was provided to government, industry, and academia in November 1990. It is resource constrained Headquarters DA guidance to the Army and industry. The document delineates Army priorities and details approximately 200 science and technology objectives, many of which will support the future systems and system upgrades identified in the Army's modernization plans. The plan states the Army's vision, strategy and roadmap to the future.

CHANGING ROLE OF ARMY LABS AND CENTERS

1940's & 50's	ARSENAL SYSTEM ARMY MATERIEL DEVELOPED AND PRODUCED PRIMARY IN-HOUSE
1960	DIVISION OF RESPONSIBILITY TECHNOLOGY BASE AND SYSTEM DEVELOPMENT REMAIN IN-HOUSE, BUT PRODUCTION SHIFTS TO INDUSTRY
1970's & 80's	COMPETITION "HIGH TECH" REVOLUTION SPREADS THROUGHOUT INDUSTRY; PUBLIC AND PRIVATE SECTORS COMPETE FOR RESOURCES
THE FUTURE	LABS AND CENTERS INTERPRET / TRANSLATE FUTURE BATTLEFIELD NEEDS AND APPLY AND INTEGRATE TECHNOLOGY DEVELOPMENT IN-HOUSE AND ELSEWHERE. THEY ALSO FILL GAPS, MAINTAIN CORPORATE MEMORY AND ACT AS SMART BUYERS

The role of our Army laboratories and centers has undergone significant change from the 1940s and 1950s. Continued process and organizational improvements are even more important today as we face a declining defense budget, reduced force structure, and the world-wide proliferation of high technology conventional arms. Correspondingly, the Army has undertaken a number of management initiatives to make the Army's 21st century research and development efforts more efficient and effective.

LABORATORY 21

OBJECTIVE

- "WORLD CLASS" BASIC & APPLIED RESEARCH
  - IMPROVED PRODUCTIVITY & QUALITY
  - REDUCED OVERHEAD
  - INCREASED CRITICAL MASS OF RESOURCES FOR SYNERGISM & FLEXIBILITY

APPROACH

- ESTABLISH "FLAGSHIP" LAB
- NUMBER OF LABS & CENTERS REDUCED
- FURTHER CONSOLIDATION THROUGH TRI-SERVICE RELIANCE (INCLUDING ASBREM)
- IMPLEMENTATION STUDIES UNDERWAY

The Army must have a "world class" research and development system for the challenges of the 21st century. A productive, efficient research environment, consisting of quality people and modernized facilities is needed. Productivity will improve with the quick assembly of creative blends of talent and technology, more effective communication and coordination, and ease of technology transfer. Efficiency improvements result from reducing overhead, reducing management layering, and eliminating duplication of effort. A productive and efficient research environment requires quality facilities conducive to attracting and retaining the scientists and engineers who will provide the "critical mass" of talent fundamental to "world class" research. It is not surprising that we can best describe the Army research and development establishment of the 21st century like the 21st century Army—a smaller, more versatile, higher technology force.

The Army initiated our LAB 21 study to meet this challenge. A set of uniform guiding principles was applied to our existing organizational structure of labs and centers. All proposals emanating from the study were placed into one of two categories: (1) those involving organizational realignments, closures, and construction which require environmental impact analysis; and (2) those involving managing changes which can be implemented as quickly as supporting policies, procedures, goals and methods to measure effectiveness can be put in place. Regardless of the category, each and every proposal had to pass the test of improving efficiency and effectiveness while positioning our research and development organizations to satisfy Army research needs for the 21st century.

ARMY RESEARCH AND DEVELOPMENT DOMAINS

Combat Materiel	Infrastructure & Environmental Quality	Medical	Manpower, Personnel & Training
• Weapons • Sustainment Items • Soldier Items • Combat Support • Combat Service Support	• Installation Support • Environmental Quality • Coastal Engr • Construction • National Waterways	• Military Disease Hazards • Combat Casualty Care • Med Biological Defense • Army Systems Health Hazards • Environmental Medicine	• Recruit, Select Classify, Retain • Leader Development • Unit Training • Individual Skill Development • Training Analysis & Development

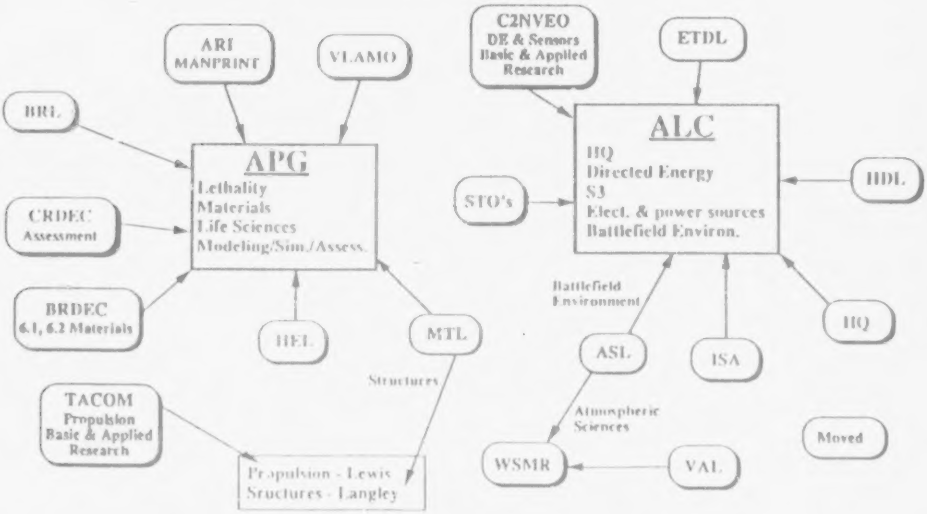
Army research and development can be grouped into four distinct domains: combat materiel; infrastructure (civil works and military); medical; and manpower, personnel and training. Each is unique in its focus, customer base, product line, and product approval and acquisition process.

The Army included our LAB 21 program under our Base Closure and Realignment Act of 1990 submission. This 6-year program is designed to improve the quality, productivity and efficiency of Army research and development organizations, while increasing their ability to attract and retain high quality scientists and engineers.

One of the key elements of LAB 21 is the creation of a world class "flagship" laboratory called the Combat Materiel Research Laboratory (CMRL). If approved, the CMRL would be headquartered at Adelphi, MD, home for the following Directorates: Signatures, Sensors and Signal (S3) Processing; Battlefield Environmental Effects; Electronics and Power Sources; and Directed Energy.

Lethality, Materials, Life Sciences and Simulation/Modeling/Assessment Directorates of CMRL would be located at Aberdeen Proving Ground, MD, where extensive test and range capabilities already exist.

CMRL Option I
ALC/APG



Specific realignments for the CMRL follow:

(1) Move the Army Research Institute (ARI) MANPRINT function from Alexandria, VA, to CMRL, Aberdeen Proving Ground, MD.

(2) Move the basic and applied materials research elements from the Belvoir Research and Development Center, VA, to CMRL, Aberdeen Proving Ground, MD.

(3) Move the Army Materials Technology Laboratory (AMTL) (less structures element) from Watertown, MA, to CMRL, Aberdeen Proving Ground, MD (Change to the recommendations of the 1988 Base Closure Commission).

(4) Move and combine the AMTL structures element with the Army Aerostructures Directorate collocated at NASA-Langley Research Center at Hampton, VA. Expand the mission at that site to form a CMRL Structures Directorate (Change to the recommendations of the 1988 Base Closure Commission).

(5) Move the directed energy and sensors basic and applied research element of the Center for Night Vision and Electro-Optics at Fort Belvoir, VA, to CMRL, Adelphi, MD.

(6) Move the Electronic Technology Device Laboratory from Fort Monmouth, NJ, to CMRL, Adelphi, MD.

(7) Move the battlefield environment effects element of the Atmospheric Science Laboratory at White Sands Missile Range, NM, to CMRL, Adelphi, MD.

(8) Move ground vehicle propulsion basic and applied research from Warren, MI, and combine with the Army Aviation Propulsion Directorate collocated at the NASA-Lewis Research Center in Cleveland, OH, to form the CMRL Propulsion Directorate.

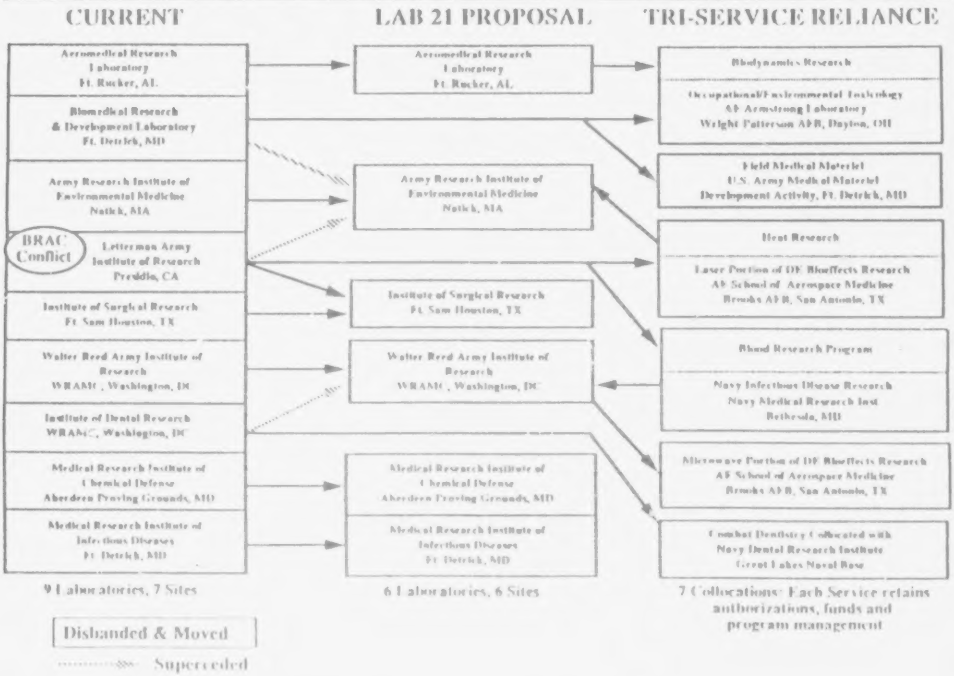
(9) Move the Harry Diamond Laboratories Woodbridge Research Facility element to CMRL, Adelphi, MD, and close/dispose of the Woodbridge, VA, facility.

(10) Move the fuze development and production mission (armament related) from Harry Diamond Laboratories, Adelphi, MD, to Picatinny Arsenal, NJ.

(11) Move the fuze development and production mission (missile related) from Harry Diamond Laboratories, Adelphi, MD, to Redstone Arsenal, AL.

Under the Tri-Service Project Reliance study, the number of Army medical research labs would be reduced from nine to six, while seven tri-service medical programs would be collocated at single service sites. Realigning medical research laboratories and programs achieves efficiencies through inter-department consolidations, transfers and reliance in technology.

Medical Research & Development Realignments


CURRENT
LAB 21 PROPOSAL
TRI-SERVICE RELIANCE
Aeromedical Research Laboratory Ft. Rucker, AL
Biomedical Research & Development Laboratory Ft. Detrick, MD
Army Research Institute of Environmental Medicine Natick, MA
BRAC Conflict
Letterman Army Institute of Research Presidio, CA
Institute of Surgical Research Ft. Sam Houston, TX
Walter Reed Army Institute of Research WRAMC, Washington, DC
Institute of Dental Research WRAMC, Washington, DC
Medical Research Institute of Chemical Defense Aberdeen Proving Grounds, MD
Medical Research Institute of Infectious Diseases Ft. Detrick, MD
9 Laboratories, 7 Sites
Aeromedical Research Laboratory Ft. Rucker, AL
Army Research Institute of Environmental Medicine Natick, MA
Institute of Surgical Research Ft. Sam Houston, TX
Walter Reed Army Institute of Research WRAMC, Washington, DC
Medical Research Institute of Chemical Defense Aberdeen Proving Grounds, MD
Medical Research Institute of Infectious Diseases Ft. Detrick, MD
6 Laboratories, 6 Sites
Biodynamics Research
Occupational/Environmental Toxicology AF Armstrong Laboratory Wright Patterson AFB, Dayton, OH
Field Medical Materiel U.S. Army Medical Materiel Development Activity, Ft. Detrick, MD
Heat Research
Laser Portion of DE Bioeffects Research AF School of Aerospace Medicine Brooks AFB, San Antonio, TX
Blood Research Program
Navy Infectious Disease Research Navy Medical Research Inst Bethesda, MD
Microwave Portion of DE Bioeffects Research AF School of Aerospace Medicine Brooks AFB, San Antonio, TX
Combat Dentistry Collocated with Navy Dental Research Institute Great Lakes Naval Base
7 Collocations: Each Service retains authorizations, funds and program management
Disbanded & Moved
Superceded

Specific realignments follow:

(1) Disestablish the Letterman Army Institute of Research (LAIR) as part of the closure of the Presidio of San Francisco, cancel the design and construction of the replacement laboratory at Fort Detrick, MD and realign LAIR's research programs in the following manner (Change to recommendations of the 1988 Base Closure Commission):

—Move trauma research to the U.S. Army Institute of Surgical Research, Fort Sam Houston, TX.

—Move blood research and collocate with the Naval Medical Research Institute (NMRI), Bethesda, MD.

—Move laser bioeffects research and collocate with the U.S. Air Force School of Aerospace Medicine (USAFSAM), Brooks Air Force Base, TX.

(2) Disestablish U.S. Army Biomedical Research Development Laboratory at Fort Detrick, MD, and transfer medical materiel research to the U.S. Army Medical Materiel and Development Activity at Fort Detrick and collocate environmental and occupational toxicology research with the Armstrong Aerospace Medical Research Laboratory (AAMRL) at Wright-Patterson Air Force Base, OH.

(3) Disestablish the U.S. Army Institute of Dental Research, Washington, DC, and collocate combat dentistry research with the Naval Dental Research Institute at Great Lakes Naval Base, IL.

(4) Move microwave bioeffects research from Walter Reed Army Institute of Research (WRAIR), Washington, DC, and collocate with USAFSAM.

(5) Move infectious disease research from NMRI and collocate with WRAIR.

(6) Move biodynamics research from U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, and collocate with AAMRL.

(7) Move heat physiology research from USAFSAM and collocate with U.S. Army Research Institute of Environmental Medicine (USARIEM), Natick, MA.

The LAB 21 and Tri-Service Project Reliance programs will revitalize the Army's laboratories and strengthen the Army's ability to execute its research and development plans. This will assure the Army has the needed technology to address 21st century challenges. This program has been guided by the fact that today's soldier benefits from the world's best technology and tomorrow's soldier deserves no less.

CRITERIA CROSSWALK

CMRL FACTORS	BRAC CRITERIA Mission	Land & Airspace	Contingency/Mobil.	Cost & Manpwr.	ROI	Community Impact	Infrastructure Suppt.	Environ. Impact
Academic Prox.	X						X	
Qual. of Life	X					X	X	
Local Workforce	X		X	X		X	X	
Real Estate	X	X	X					
Environ. Impact	X					X		X
Local Infra.	X			X		X	X	
Multi-Disc. Teaming	X		X					
Consortia Opport.	X		X					
Tech. Adapt.	X							
Long Range R&D	X							
Obj/Independ. Assessment	X	X	X	X				
Customer Coupling	X							
Cost Analysis				X	X	X		

Our organizational design for the laboratories was driven by our modernization vision, strategy, and action plan as documented in the Army Technology Base Master Plan (ATBMP). Extensive analyses of numerous alternatives were conducted using a uniform set of evaluation factors and attributes. The LAB 21 factors used were consistent with and complementary of those used for the 1991 Base Realignment and Closure analyses, and represent those considerations which are critical to increased productivity and quality of products and services.

Numerous configuration and site alternatives for CMRL were evaluated using the following weighted factors and related attributes:

(1) *Academic Proximity* to institutions of higher learning which are proven performers in research and technology.

(2) *Quality of Life* which would enhance recruitment and retention of a critical mass of scientists and engineers.

(3) *Local Workforce*, including experienced scientists, engineers and support personnel, which provide flexibility in hiring employees to respond to changing research and technology, and administrative program emphases.

(4) *Real Estate* for sufficient for occupancy of, or the construction of, modern laboratory facilities and offer flexibility in accommodating either on-site or adjoining experimentation ranges and facilities.

(5) *Environmental Impact*.

(6) *Local Infrastructure* either in place or planned, so as to provide priority and quality services to the laboratory.

(7) *Multi-Disciplinary Teaming Opportunity*—A single campus provides the best configuration.

(8) *Consortia Opportunities* for technology generation, transfer and the development of personnel via teaming arrangements and the sharing of facilities with institutions within reasonable proximity of CMRL.

(9) *Technical Adaptation* weighs the merits of being the right size to adapt as the "technological birthrate" increases. The larger the population on a single campus, the easier it is to adapt.

(10) *Long Term and Entrepreneurial Research* is the ability to pursue high risk and high payoff research unburdened by proximity to the customer.

(11) *Customer Coupling* is the ability to assist in developing research and technology requirements, transition technology, and establish an efficient and effective customer/supplier relationship.

(12) *Objective/Independent Assessment* must be independent from the research and technology generation mission.

Costs and savings for LAB 21 were considered separately from the above evaluation factors and attributes. In the final analysis, however, they were major factors in the alternative selection process. All construction costs were estimated and provided by the Army Corps of Engineers. These estimated construction costs, coupled with the estimated costs for moving equipment and personnel, hiring personnel, terminating personnel, and savings associated with each personnel reduction, were entered into a costing model. This model, the Cost of Base Realignment Action (COBRA) model, assessed the relative economic value of proposed realignments or closure actions.

The Army is participating extensively in the Defense Laboratory Demonstration program. Army demonstration laboratories and centers are: all seven Army Laboratory Command corporate laboratories; the AMC Missile Research, Development and Engineering Center; the Corps of Engineers Waterways Experiment Station; and all laboratories of The Surgeon Generals' Medical Research and Development Command. Army initiatives fall into the following categories and reflect the underlying philosophy of the Office of Technology Assessment report "Holding the Edge."

In the area of *management authority:*

(1) We have transferred support organizations (civilian personnel, procurement, general counsel and facilities maintenance) to the operational control of the laboratory and center directors. While specific implementation varies from organization to organization and function to function, in all cases the ability of the corporate leadership to execute its research and development mission has been strengthened;

(2) At two of the three organizations which have civilian Directors, each have been appointed for a minimum of 4 years, with subsequent renewal possible if deemed desirable. The other laboratory deemed this action unnecessary, as the average tenure of the past two Directors has been 30 years. The nine Medical Research and Development Command laboratories have military Directors/Commanders, but will institutionalize a 4 year tenure beginning in August 1991.

In the area of *personnel:*

(1) We have extended the career track for world-class scientists to the Scientific/Technical (ST) Corps (equivalent to GS-16 through GS-18 in pay). This year 22 additional ST positions were approved by the Office of Personnel Management, bringing the Army's authorized ST strength to 29. Twelve of these 29 ST positions are in the Army's demonstration laboratories.

(2) We are participating in the testing of automated personnel documentation systems as part of the effort to delegate personnel classification authority to managers.

(3) We have obtained authority to direct-hire PhD's for the GS-9/11/12 levels for all demonstration laboratories. Since July 1990, the demonstration laboratories have appointed 16 PhD's using this direct hire authority. This accelerates the recruiting process by 3 to 5 months.

In the area of *contracting:*

(1) We have authorized demonstration laboratory and center directors to use alternatives to the Army's Supply System for small purchases (under $25,000). Using this discretionary authority, we have seen significant improvement in the timeliness and efficiency of small purchases. We have seen specific examples where the waiting time from request to receipt of equipment has dropped from 100 days to a week or less.

(2) Scientists and engineers at nine of our demonstration laboratories have been given limited ordering authority for small purchases (under $2,500). This has been achieved through use of the government-wide commercial credit card service. Our test sites using this card report great success and satisfaction with this initiative. Critical supplies and materials are often obtained in 1 to 2 days, thus reducing downtime on priority technology projects. The Director of Harry Diamond Laboratories estimates that this has saved $3.6 million to $5 million per year in engineer and scientist downtime alone for fiscal years 1989 and 1990.

(3) We have encouraged the maximum use of grants, Broad Agency Announcements and Small Business innovation Research Contracts which take one-third the time of the normal contract action process.

In the area of *facilities and equipment:*

We have strengthened the authority to purchase scientific equipment, computational systems and laboratory special purpose equipment. All of the AMC laboratories and the Waterways Experiment Station are now using a laboratory overhead account to purchase modern equipment.

In summary, the Army is responding to worldwide political, economic, and technological change by making fundamental improvements in its organizational management and philosophy across the entire spectrum of its responsibilities. The cumulative effect of these actions is a major institutional change to enhance productivity and quality. Maintaining a strong Army technology base in the face of declining budgets is indeed a real challenge; but the initiatives and proposals I have outlined are designed to meet this challenge head-on.

Mr. Chairman, thank you again for this opportunity to appear before the committee, and I'd be happy to answer any questions you may have.

Senator BINGAMAN. Thank you very much. Mrs. McBurnett, why do you not go ahead.

STATEMENT OF GENIE McBURNETT, PRINCIPAL DEPUTY ASSISTANT SECRETARY OF THE NAVY, RESEARCH, DEVELOPMENT AND ACQUISITION

Mrs. McBURNETT. Thank you, Mr. Chairman, distinguished members of the subcommittee.

It is indeed a pleasure to be here today, particularly because I headed the working group that developed the Navy's concept for internal consolidation and then further guided the plan. With your permission, I would like to also submit a copy of that plan approved by the Secretary of the Navy for the record and for your information.

Senator BINGAMAN. We would be glad to have that.

Mrs. McBURNETT. The Navy's internal consolidation planning has its roots back in many, many studies, but the effort that we will be talking about today really took its final form, starting with an effort in August of last year, when the Secretary of the Navy formed a high level working group, with representation from both the requirements generators, the Systems Commands, and the Secretariat staff, to look at a concept for internal consolidation in the Navy.

I would have to say that, at that point, one of the main drivers was to make things better and to be more efficient. As I go through this, I will tell you that that particular driver became less important to something else as we went along.

We looked, initially, at 76 activities that expend RDT&E money outside of our Systems Commands, and focused on 36 of those, which were really the core activities who do our research, development, test and evaluation, and engineering support. Those activities have an annual business base of over $9 billion.

It is important to understand that although we started with RDT&E, the business base is really just slightly over one-third RDT&E, with the other almost two-thirds being funded out of our procurement and support accounts. So, the 36 activities truly are already very broad-based activities. They employ 65,000 people. So, it is a large set of activities that we have brought together.

In December of last year, the Secretary supported the concept initially brought forward to him and asked for more detailed planning to be done. The concept that we gave him at that time called for four, full-spectrum warfare centers, full-spectrum in the sense that they would have work from basic research and science and technology, to the R&D in the development of our programs, through product and product improvement, as well as fleet support.

In addition, we would have a streamlined corporate laboratory structure that would have as its mission, a broad-based program of scientific research and advanced technological development. Important to the concept is that each of the warfare centers and the corporate laboratory would be assigned unique sets of technical leadership areas that they would work in.

In January, after the concept was supported and the Secretary asked for more detailed planning, we expanded the group that was doing this planning considerably. We brought in the key people from the field activities to bring their knowledge and facts to bear so that we could do this as best informed as we could be.

Another thing happened while we were planning, and this is the thing that probably changed our focus. Last fall, as you are aware, there were several very significant pieces of legislation that affected this effort.

The first, of course, was the establishment of the Base Closure and Realignment Commission. That was established after we had begun our planning. This legislation made it clear to us that any changes that we proposed that were significant, would go through a fairly structured process, both internal to OSD, and as well as with the Congress through the Commission.

The Authorization Act, itself, mandated a 4 percent per year or 20 percent cut in the acquisition workforce. The way that the cut is structured it affects all 65,000 people at all of these activities.

But finally, and probably most importantly, the Budget Enforcement Act sent a very definite message and it crystallized what probably many in the Navy had been thinking about. The Navy's budget that funds the work of these activities would drop by more than 20 percent over the next 5 years.

The implication of that was clear. Along with the reduced force structure, the Navy's RDT&E and engineering support infrastructure must get smaller. Second, the Navy felt strongly that that infrastructure was sufficiently important, sufficiently fragile, that that downsizing, whether driven by people reductions or driven by the reduction in money that would pay for its work, could not be handled in a haphazard way. So consolidation became, for us, not just a way to become more efficient, but a way to preserve a core mission capability that will allow us to respond flexibly, both to the downsized fiscal environment, as well as to the needs that the Navy might place on us at any given time.

Our overriding concern, then, in our plan was preserving that core mission capability. We did this partly through purification of the missions at the centers, and the unique assignment of leadership areas. But we also, through the consolidation, feel that we can achieve significant savings in overhead.

That means for us, that for every dollar that we do get to spend on program, we can put more of that dollar into real technical work and less of that money into paying administrative costs, military construction costs, and maintenance of activities, if we, in fact, have fewer activities to support and fewer administrative sorts of segments to support.

In April 1991, as required because the changes were significant, the Secretary of the Navy submitted this plan to OSD for submission to the Base Closure and Realignment Commission. I should say that, although not all of the actions would have passed the thresholds of the legislation, the plan was submitted as a total entity. It was created to be integrated and is highly interwoven. The pieces play together and fit together and so could be best understood and reviewed as a complete plan.

The Navy still has some significant work to do, even as we await the outcome of the Base Closure and Realignment Commission reports. We are continuing our planning and discussion. We need to look at how we can best translate these changes and help our people through them, because there are large numbers of people and functions that could be moved with this consolidation. We need to look at our financial systems, and our contracting and procurement systems.

That brings me to just a brief discussion of the Laboratory Demonstration Program. I think both Mr. Adolph and Dr. Singley have covered that. Much of what they have discussed applies equally to the Navy. The Navy is delighted with that effort and very much appreciates the participation and the initiative of this committee in setting it up.

It has benefited us greatly already. We will continue to use it, to be guided by it, as we go forward and set the path for our future centers, balancing between what we can apply broadly and what really must remain a demonstration program. But, in working with our people changes, our financial changes, our contracting, and management changes, the Laboratory Demonstration Program has already proven its value.

One thing that I do not want to leave out is our relationship with the world outside of our laboratories and centers; industry and the university labs. Some people might say that one way to accommodate this lowered funding is simply to close the gates, pull up the draw bridge, and bring everything in-house. That is absolutely not our intent. In fact, this streamlining makes our relationship with the industry even more important. We must continue to strengthen the strong partnership that we have in industry. We recognize our responsibility to share with industry the responsibility for development of our tech base and of our technological programs.

So, as we streamline, we will continue to respond to that responsibility and to support our industry partners, both in our corporate laboratory and in our warfare centers.

In conclusion, I feel that the Navy has gone through a difficult, rigorous process. It has been fully participative. We have formed a structure that we think will allow us to preserve something that is absolutely at the heart of the ability of the Department of the Navy to achieve its mission: to go where it is called to go. We feel that we have achieved a way to preserve our core technical capability and preserve it in a way that we can fund it, allow it to respond flexibly when it is called upon, and allow it to form the lead it should have in certain areas in the technological advancements of the next century.

Thank you very much.

[The prepared statement of Mrs. McBurnett follows:]

PREPARED STATEMENT BY GENIE MCBURNETT, PRINCIPAL DEPUTY ASSISTANT SECRETARY OF THE NAVY (RESEARCH, DEVELOPMENT AND ACQUISITION)

Mr. Chairman and distinguished members of the subcommittee, I am pleased to have the opportunity to participate in the hearings concerning the Department of

Defense in-house laboratory system. I am particularly pleased in that I chaired the working group that was responsible for developing the Department of the Navy Research, Development, Test and Evaluation (RDT&E), Engineering and Fleet Support Activities Consolidation Plan. With the Chairman's permission, I would like to submit a copy of that plan for the record.

The consolidation of RDT&E, engineering and fleet support activities initiative began in October 1989 as a result of the Defense Management Report (DMR). At that time, the draft version of DMR Decision (DMRD) 922, entitled "Consolidation of (R&D) Laboratories and T&E Facilities," was released. Throughout the following year, under the guidance of the Director, Defense Research and Engineering (DDR&E), the services worked to develop a plan to achieve the required consolidation.

As the negotiations with the services and DDR&E continued, it became apparent that the Navy needed to prepare preliminary plans for internal consolidation regardless of the final form that DMRD 922 would take. As a result, in August 1990, the Secretary of the Navy formed the RDT&E Facilities Consolidation Working Group. The working group was composed of representatives from the Navy Secretariat, each of the affected Systems Commands, the Office of the Chief of Naval Operations, the Headquarters, Marine Corps, the Chief of Naval Research, and the Office of the Comptroller of the Navy. The Secretary tasked the working group with developing the initial plans for the internal Navy consolidation. As part of his tasking he directed the working group to examine all activities that expend RDT&E funds.

The working group identified 76 activities that expend RDT&E funds. Upon closer examination, we discovered that a number of activities, such as training and education activities, depots, and Superintendents of Shipbuilding, expend RDT&E funds for very specific purposes and are not involved in broad-based research and development or engineering support. For this reason, they were eliminated from further consideration. Also eliminated from consideration were 14 activities that were identified for possible Tri-service cooperation. The final scope of the consolidation includes 36 activities encompassing nearly 65,000 personnel with an annual business base of over $9 billion. Of this total business base, just over one third is funded in the RDT&E appropriation, the remainder represents procurement, support, and other funding.

In November 1990, the Deputy Secretary of Defense signed DMRD 922. Under this decision each of the services was directed to consolidate their RDT&E facilities internally while pursuing inter-service reliance in Science and Technology and Test and Evaluation.

The RDT&E Facilities Consolidation Working Group presented a consolidation concept to the Secretary of the Navy in December 1990. The Secretary supported the concept and directed that the Systems Command Commanders and the Chief of Naval Research develop detailed plans for implementing the concept. With this direction, the number of people involved in the consolidation planning increased significantly. The Commanding Officers and Technical Directors of each of the activities affected were brought into the process. There were also subordinate working groups within each of the Systems Commands established to coordinate the detailed planning.

The concept upon which the consolidation is based centers around the formation of four full-spectrum Warfare Centers and the streamlining of the Navy's Corporate Laboratory. These centers are aligned by mission and are full spectrum in the sense that their responsibility spans the entire range of system development from early development through direct, fleet in-service engineering support. The corporate Laboratory will continue to pursue a broad program of scientific research and advanced technological development. Each of the centers and the Corporate Laboratory are assigned a unique set of technical leadership areas.

In the fall of 1990, the Congress passed several pieces of legislation that affect the consolidation. The Budget Enforcement Act of 1990 places caps on the budget for the next 5 years. As a result, the Navy's Total Obligation Authority (TOA) decreases by more than 21 percent over 5 years. The Defense Authorization Act for fiscal year 1991 mandates a 20 percent reduction of the Acquisition Workforce over 5 years. The effect of either of these is large enough to significantly decrease the amount of in-house work that the Navy will be able to perform. The size of our RDT&E and in-service engineering support infrastructure will decrease. Consolidation is the plan by which we will carefully manage this reduction rather than let it occur in an uncontrolled fashion. Consolidation will permit us to significantly reduce our overhead which, in turn, will let us increase the share of funds that can be applied to direct labor. The overriding concern in developing the plan is to preserve the Navy's core mission capability to perform research, development, test and evaluation, in-service engineering and fleet support while accommodating the mandated reductions in both funding and personnel. A key aspect of the consolidation is the purification of each center's mission through the assignment of unique technical leadership areas. This purification will not only reduce unwarranted duplication of effort, but will also create a critical mass of technical expertise in one location.

Within each of the centers, the activities were consolidated into a number of major operating sites. Selection of the consolidation site was based on a wide variety of factors. The types of issues that were considered in the selection of the consolidation sites included:

— The capabilities and facilities at each site;

— The existence of geographically unique features such as instrumented and uninstrumented ranges and restricted airspace;

— The room for expansion to accommodate the consolidation;

— The existence of unique facilities;

— The proximity of In-Service Engineering Centers to major fleet concentrations; and

— The cost and manpower implications.

I would like to comment on the way in which costs played in the development of the consolidation plans. The consolidated structure was initially designed to provide the best possible support to research and development programs and the fleet. Once the structure was defined, the costs involved in achieving the structure were estimated. In several instances, it was determined that the costs involved with that particular action were not affordable. In almost every case, the high costs were associated with moving or replicating an essential, unique facility. In these cases, the decision was made to retain the facility and the personnel to sustain it at the original location. These sites are being retained for the sole purpose of operating the existing unique facilities.

In April 1991 the Secretary of the Navy approved the Department of the Navy RDT&E, Engineering and Fleet Support Activities Consolidation Plan. In order to be in compliance with the Defense Base Closure and Realignment Act, the Secretary of the Navy forwarded the realignment and closure actions contained in the plan to the Office of the Secretary of Defense (OSD) as part of the Navy's submission to the Defense Base Closure and Realignment Commission. These actions were included in the recommendations that the Secretary of Defense announced on April 12, 1991 and forwarded to the Commission. The actions that were forwarded to the Commission were subjected to a complete evaluation against the formal Base Closure and Realignment Criteria by both the Navy consolidation working group and the Navy's Base Structure Committee. As part of this evaluation, the costs associated with the closures and realignments were estimated using the GAO-approved COBRA model. Community, economic, and environmental impacts were also evaluated. The detailed data for each of the effected activities were forwarded to the Congress as TAB F of the Department of the Navy Base Closure and Realignment Recommendations Detailed Analysis dated April 1991.

While the consolidation plan is approved, there are still significant issues associated with its implementation. There is an ongoing, top-level effort to deal with these issues. This effort takes the form of a sub-working group to address each specific issue. The issues being worked include:

— dealing with the impact of the consolidation on our people,

— devising the financial system or systems that will best save the consolidation,

— identifying the barriers to implementing the consolidation plan,

— determining the structure of the procurement channels and the location of the Head of Contracting Activity, and

— developing an approach to implementing the Laboratory Demonstration program in the consolidated structure.

Let me follow up on Mr. Adolph's general overview of the Laboratory Demonstration Program (LDP) and provide the committee with specific Navy comments regarding this important initiative. The Navy considers LDP vital to future laboratory effectiveness. We clearly recognize the initiative of, and support from, this committee in making this Defense Department-wide Program a success.

I am pleased to state that the Navy has been an especially active member of the OSD committee set up to develop new laboratory management initiatives under LDP. Navy has provided over 20 high level civilian employees and officers to the OSD LDP oversight committee and its subcommittees and, in fact, Navy has chaired the key panels on Personnel, Management Initiatives, and Contracting. We are vitally interested in the success of this effort because it provides a unique opportunity to demonstrate new, efficient management ideas presently not encouraged by custom or provided for in regulation or law. Many of the initiatives that fall within the purview of the military departments have been fully or partially implemented in the Navy. A few of these initiatives in areas of personnel, contracting and MILCON are:

— provided civil service position classification authority to Laboratory leadership;

— extensive use of temporary assignment authorities, such as the Intergovernmental Personnel Act, summer facility research program and the National Academy of Sciences and Office of Naval Technology post-doctoral fellowship programs to creatively attract top talent to our labs;

— received direct hire authority for PhD scientists and engineers up to GS-12 level;

— reduced oversight for low business risk R&D procurements;

— expanded Procurement Warrant Authority for Small Purchase Agents to maximum allowed by law; and

— eliminated lengthy technical reviews for minor construction projects below $100K;

Let me summarize Navy's commitment to LDP. We believe it is vital to retaining quality people, facilities and S&T programs. We want our Laboratory directors to have the wherewithal and authority to meet their objectives in a timely and efficient manner. We will continue to play a strong role in developing and promoting LDP initiatives.

Finally, I would like to provide the committee with the Navy's views on the future of its technological infrastructure. We have used a rigorous and fully participative process to examine and define a future course for Navy technology and its infrastructure. We believe it provides, through the new Warfare Centers and the streamlined Naval Research Laboratory (NRL), the ability to retain core Navy research and systems capabilities and the flexibility we will need to manage in a fiscal environment with reduced support to many acquisition programs. Streamlining the Navy technological infrastructure in no way reduces our need to share development responsibilities with industry. If anything, it makes such partnership even more imperative. We are on a path which assures that the Navy has the core in-house capabilities in some areas, and capitalizes on industry's capabilities where they are stronger.

Navy also continues to recognize its responsibility to the national infrastructure and technical health. Developments in industry and academia will continue to be extremely important, as approximately half of Navy's S&T funding is invested outside the Navy. Both NRL and the Warfare Centers have a close and necessary coupling with industry; one might say a mutual dependence on one another. I am pleased to report that 34 Cooperative R&D Agreements have been forged between Navy Labs/R&D Centers and industry, and 6 more are in preparation now. We are enjoying success in our Small Business Innovative Research program, which involves all of our Labs, R&D Centers and Systems Commands.

Realities of manning, funding and national priorities demand that the Navy position itself for a future characterized by cooperative R&D efforts. We have established plans to maintain our core in-house Navy capabilities; however, it is just as essential to the Nation to maintain our academic and industrial technology base to assure our ability to counter the technologically sophisticated threats that can be expected in the future.

Senator **BINGAMAN**. Thank you very much. We appreciate that. General Condon, why do you not go ahead.

STATEMENT OF PAT CONDON, BRIG. GEN., ACTING DIRECTOR FOR SCIENCE & TECHNOLOGY, ASSISTANT SECRETARY OF THE AIR FORCE, ACQUISITION

General **CONDON**. Thank you, Mr. Chairman.

Members of the committee, ladies and gentlemen, I am pleased to appear before this committee this morning to discuss the Air Force's Science and Technology program with you and to share some thoughts about the exciting things that are happening in the Air Force laboratories.

Since we met last year, there have been some dramatic changes in the Air Force lab structure and the processes used in our technology, research, and development. In December of last year, we announced the formation of four super labs, labs that are multidisciplined, modeled after leading national laboratories.

These labs focus on technology from basic research through advanced technology demonstration, 6.1 through 6.3A, and are addressing the following four major areas. Air vehicle technologies at the Wright Lab, at Wright-Patterson Base, Ohio; command, control, communications, and intelligence technologies at the Rome Lab, Griffiss Air Force Base, New York; human systems technologies at the Armstrong Lab, Brooks Air Force Base, Texas; and space and missiles technologies at the Phillips Lab, Kirtland Air Force Base, New Mexico.

The formation of these four labs is the latest step in a 20-year evolutionary process that has shifted the Air Force lab concentration from narrow, highly focused technologies, to an interdisciplinary approach for developing technologies for new systems.

My colleagues have already mentioned Project Reliance, and I agree with Mr. Adolph, that Project Reliance is achieving an unprecedented degree of inter-service cooperation. Through this approach, we are able to establish a critical mass of resources to develop world class technology products.

Examples include fuels and lubes work, collocated at the Wright Lab with the Army as our partner. The Air Force has shifted its unmanned ground vehicle work to the Army. The directed energy bioeffects work is to be collocated at the Armstrong Lab with both the Army and the Navy as partners. So far, over 186 agreements have been reached between the services on various technical efforts.

We are also very excited about the results to date of the Laboratory Demonstration Program. In the Air Force, the Wright Lab and the Rome Lab are participants. So far, the Air Force labs have identified 58 initiatives aimed at improving the way we do lab business, and nearly two thirds of them have been approved.

The initiatives range from the elimination of relatively minor annoyances to very significant items, such as the congressionally approved increase in salary rates for government scientists and engineers so that we might be competitive with private sector salaries. The Laboratory Demonstration Program continues to show great promise in enabling us to improve our ways of doing business in our labs and in helping us to attract and retain national caliber researchers.

Last year, the Air Force began an effort to grow our own Ph.D's. This effort, known as Palace Knight, recruits college graduates or those working on masters degrees, with the offer of employment in an Air Force laboratory and a chance to return to school with the ultimate goal of achieving a doctorate. So far, the results have exceeded even our high expectations. In the last 2 years, we have hired 69 individuals with offers currently out to an additional 26.

There is a complementary program for people with masters degrees or who are currently working on doctorates, and that program is called Senior Knight. We have hired 23 and have offers out to 19 more. The quality of the recruits is extremely impressive. The average grade point average is over 3.6 with tough academic majors in engineering and science from some of the Nation's top universities.

We have also maintained the link to the university community through our summer faculty research program. In this program, we have 150 faculty members performing summer research in Air Force laboratories. In addition, we have provided, 25 3-year lab graduate fellowships, which include summer research in an Air Force laboratory with a laboratory mentor.

For several years, we have maintained a technology link with Europe through our European Office of Aerospace Research and Development, now located in London. Recognizing the technical significance of the Pacific Rim countries, we are now in the process of establishing a similar office in Tokyo.

We also recently released a broad-area announcement to support the U.S.-Japan industry and technology management training program for the Department of Defense. The goals of the program include increasing the understanding of Japanese industry and technology management for the creative use of science and technology, and providing program participants with opportunities to be directly involved in Japanese scientific research, engineering development, and management activities. The Air Force Office of Scientific Research is handling this announcement and they are seeking proposals from institutions of higher education and nonprofit institutions.

Under the Technology Transfer and Stevenson-Wydler Technology Innovative Acts, we have been able to make very good use of the cooperative research and development agreements. We currently have several of these agreements in effect and several more in negotiation in such areas as photonics, software and modeling, avionics equipment testing, and interactive foreign language training. So far, the Air Force has licensed 12 patents through this program.

And again, in line with our links to the academic community, last month the Armstrong Lab at Brooks Air Force Base signed an agreement for an intelligent tutor system. That is a system involving interactive computer teaching with Lehigh University in Pennsylvania and with the University of Texas at San Antonio.

All of us are very proud of the performance of our troops and our equipment in Desert Storm. I am particularly proud of the responsiveness exhibited by our laboratories in supporting that effort. Most notable was the development and deployment of the GBU-28, a 5,000 pound class, hard target, guided weapon. The Armament Directorate of the Wright Lab was actively involved. They modified an existing contract to permit its rapid development, assisted in sled and drop tests, and actually filled the weapon with explosives. From contract modification to deployment in the Gulf took 3 weeks, and the weapon was used successfully.

The people at the Armstrong Lab also responded quickly to a need for providing cooling for our aircraft maintenance troops in chemical, biological protection gear. They were able to adapt a vest used by the Army for their tank crewmen, that the maintenance people could plug into a portable air conditioning unit when it became hot, then unplug and go back to work once they had cooled down. These are but two of many examples where our laboratories were able to respond immediately and effectively to support our forces in a wartime environment.

In summary, I hope you get the flavor from my comments that there are many exciting things happening in our laboratories today, exciting things happening internally as we seek ways to improve the quality of our research and the responsiveness to our customers. And exciting things happening between our laboratories and those of our sister services as we identify new ways to work together more effectively and more efficiently.

Thank you, Mr. Chairman.

[The prepared statement of General Condon follows:]

Prepared Statement by Brig. Gen. Pat Condon, Acting Director for Science and Technology, Assistant Secretary of the Air Force (Acquisition)

Mr. Chairman and members of the committee: Last year, the Air Force told Congress that we were focusing our technologies to support Secretary Rice's vision of *Global Reach—Global Power*. Operation Desert Storm has pointedly demonstrated this vision in the value of well-trained, versatile combat forces and technologically superior weapons systems that are capable of rapid deployment world-wide. Desert Storm reflects our commitment to recruiting quality people, providing them with the best equipment and technology available, training them, and giving them quality leaders to direct them.

The Air Force has remained steadfast over the years in stressing the importance of *quality* in our systems, or "maintaining the technology edge" to counter the *quantity* of enemy weapons systems. Importantly, the Congress has consistently agreed with our approach, in spite of a continued debate as to whether this is the proper course. For defense systems and products, the ultimate measure of merit is war. Using this metric, the answer seems clear, and I would like to quote Secretary Cheney in a recent congressional hearing. He said, "I thank my lucky stars that Today's Secretary, when we were at war in the Gulf, was able to deploy a force that is equipped with the resources resulting from the investment of the previous Secretaries and previous Congresses in high technology items."

Our success in Desert Storm was not an accident. The weapons used in Desert Storm resulted from a well-balanced and structured Science and Technology Program. Because of investments in technology over the last 20 years, today's forces can exploit the speed, flexibility, range, lethality, and precision of modern airpower. The Air Force Science and Technology program is the cornerstone and provides the advanced technologies needed by our current and future aerospace forces to maintain a technologically superior warfighting capability.

Today, our technology investment strategy must be developed in an environment that continues to change more rapidly than anyone could have imagined. Last year, when the Air Force met with this committee, we found encouragement in the large number of positive political and military developments throughout the world during 1989. However, we stated then that we still must base our military planning, and by extension, our research and development and acquisition of new systems, on two principal factors: (1) actual military capabilities of our potential adversaries (including Third World threats) and not an optimistic evaluation of their intentions; and (2) the recognition of our need to maintain U.S. technological superiority as we substantially reduce our forces over the coming years. The conflict in the Gulf proved to support our caution. The backbone of Air Force planning effort is our commitment to a sound Research and Development program with the Science and Technology Program providing the foundation. We have developed the Air Force investment strategy around four major points:

— Maintain Technological Superiority
— Maintain Readiness
— Develop new systems

To accomplish the second, third, and fourth of these requires a sustained investment and attention to the first—MAINTAIN TECHNOLOGICAL SUPERIORITY.

The Air Force Science and Technology program is the cornerstone for our future fighting forces. The size of the threat to the United States and its allies may be rapidly changing, but we have seen no degradation to the military quality of that threat. In fact, quite to the contrary. We have seen the dramatic evidence of that increased weapon system quality in Operation Desert Storm. While the Iraqis lacked command structure and adequate military training to mount any campaign against the coalition forces, they nonetheless possessed military equipment that was technologically advanced and capable of destroying opposing forces. High quality weapons are available to Third World nations through vigorous marketing and sales.

We must continue a broad S&T program that will provide the technologies required for future system development. This requires both adequate funding and proper allocation of the funding. The investment strategy must balance near-term and far-term technology needs among tomorrow's weapon systems needs, support of today's systems, selection and training of highly qualified scientists and engineers, and maintenance of the laboratory infrastructure. We must also develop technologies aimed at reducing the cost of future weapon systems and enhancing the "ilities" (i.g. supportability, maintainability, reliability, etc.) of those systems.

This past year has seen a major organizational change in how the Air Force manages and executes the Science and Technology Program. The most visible change has been the consolidation of all the existing Air Force laboratories into four "super" laboratories. These laboratories are larger multi-disciplinary, multi-program laboratories modeled after the recognized leading applied research laboratories in government and industry, and will result in better research integration and productivity. Each laboratory has principal program responsibility for one of four broad functional technology areas which encompass the entire Air Force Science and Technology program. The laboratories and their technology area responsibilities are: air vehicles at Wright Laboratory, Wright-Patterson AFB, OH; space and missiles at Phillips Laboratory, Kirtland AFB, NM; command, control, communications and intelligence (C3I) at Rome Laboratory, Griffiss AFB, NY; and human systems at Armstrong Laboratory, Brooks AFB, TX. Each laboratory also has responsibilities for maintaining some part of the overall technology base, such as material sciences research at Wright laboratory, and all conduct some 6.1 research coordinated by the Air Force Office of Scientific Research. This organizational consolidation was formally announced in December 1990. It is the latest step in a 20-year evolutionary process that has shifted the Air Force laboratory concentration from narrow, highly-focused technologies to an interdisciplinary approach for developing new systems.

Additionally, we are realizing increased efficiencies by consolidating and coordinating our S&T programs with the Army and the Navy. This initiative is referred to as Project Reliance, which has in fact achieved an unprecedented degree of interservice coordination and cooperation.

The objectives of Project Reliance are:

— Enhance S&T and ensure critical mass of resources to develop "world class products"

— Reduce unwarranted redundant capabilities

— Gain efficiency through collocation and consolidation of in-house work, when appropriate.

— Integrate service S&T programs with linkage to the end user

— Improve the quality of the product.

This initiative contributes to a more effective laboratory organization aligned to maximize our Science and Technology Investment. As a result of Project Reliance, there are 71 technology efforts where the services will jointly plan for work to be conducted at separate service locations. There are 105 technology efforts where work will be collocated to various single-service site locations for execution. Service leads are designated for another 10 technology efforts. Two examples: the Army and Air Force S&T work in fuels and lubes will be collocated at Wright-Patterson AFB, OH; and the Army will remain lead for work in unmanned ground vehicles. Project Reliance has yielded substantial positive changes for achieving increased efficiencies through joint S&T programs, collocations, and consolidations. Project Reliance is intended to be a continuing process in guiding the future S&T planning process.

Another major new initiative in the DOD, aimed at improving the laboratory research environment, is the Laboratory Demonstration Program. Demonstration laboratories have been selected to explore new ways to recruit and retain scientists and engineers, streamline contracting procedures, and improve our aging research facilities. This demonstration program sends the signal that our service laboratories are important to the Nation, and has created excitement and enthusiasm all the way down to the bench-level scientist and engineer. Two of our laboratories, Wright Laboratory at Wright-Patterson AFB, OH and Rome Laboratory at Griffiss AFB, NY are the Air Force demonstration laboratories. We are confident that these two laboratories will demonstrate greater efficiency and improved productivity as a result of the laboratory demonstration initiatives. Our goals are to maintain a high quality research environment and attract and keep quality scientists and engineers.

We have already seen some accomplishments from the Laboratory Demonstration Program. For example, in the contracting area, the threshold for Senior Procurement Executive Acquisition Plan approval has been raised from $10 million to $25 million. This will reduce time and paperwork involved in awarding contracts in this dollar range. In another instance, selected researchers may now buy small-dollar R&D support items with government-issued credit cards, reducing time and paperwork. In the personnel area, Congress has approved special salary rates to make government scientists and engineers starting salaries more competitive with the private sector. We may now also attract expert Federal retirees for specific projects, with full pay in addition to their annuities. in the management area, funds and expenditure data will now be transferred electronically, thereby improving program financial execution. These are but a few of the initiatives undertaken by the Laboratory Demonstration Program. Of the 58 total initiatives, 35 have already been approved. The remaining initiatives are still in the evaluation and review process.

The Investment Strategy for the Air Force Science and Technology Program involves a yearly iterative process that involves several inputs, including the Defense Guidance and the *Defense Critical Technologies Plan* issued by Director Defense Research & Engineering. The Air Force Acquisition Executive subsequently issues his Guidance Memorandum to Air Force Systems Command. The laboratories use these inputs, along with other guidance from Air Force Systems Command, to develop *Technology Area Plans* (TAPs) in the following 12 technology areas: Materials, Civil & Environmental Engineering, Air Vehicles, Research, C3I, Avionics, Conventional Armament, Advanced Weapons, Aero Propulsion & Power, Space & Missiles, Geophysics, and Human Systems. The Air Force operational commands evaluate our major technology demonstration programs for relevancy and need and the Air Force Scientific Advisory Board evaluates them for quality; their feedback is used to adjust scope and content of each technical program. The Air Force through a new management process is redoubling its efforts to assure the "operators" have a significant voice in our Science and Technology Program. In September, the Air Force Acquisition Executive approves the TAPs for execution starting in October.

As previously mentioned, an input to the Air Force Investment Strategy for the S&T program is the *DOD Critical Technologies Plan*. The *DOD Critical Technologies Plan* provides focus and definition of important relevant technologies that could meet military needs for our laboratories, industry, and our international partners. However, it is important that we must never lose sight of the fact that we develop technologies to meet the future capability needs of our warfighters, and that our technology investment strategy reflect this priority.

While we find the selected critical technologies an excellent method of advocating, highlighting, and increasing attention paid to these important technical areas, it is a limited list and does not represent the broad range of technology efforts that must be supported to maintain a full-spectrum warfighting force. We therefore urge caution in trying to use the Critical Technologies as the primary investment strategy input in the Science and Technology budgeting process. We must also insure that a balanced approach to technology development occurs across the aerospace technology base.

While our number one S&T role is to develop technology to serve the operational Air Force, at the same time many of our technological developments will also have civilian commercial applications (such as carbon-carbon materials for graphite fishing poles, artificial hips, and golf clubs). Given today's austere budget environment, the Air Force and private sector laboratories must continue to identify and implement processes that more effectively utilize advanced technologies that were developed for military applications but which significantly contribute to maintaining the United States overall technological competitiveness. By enacting the Stevenson-Wydler Technology Innovation Act (1980) and the Federal Technology Transfer Act (1986), Congress has helped create the environment to facilitate commercialization of military-related technologies. The Air Force supports these acts and is building the infrastructure necessary for capitalizing on the benefits available from complete implementation.

As mandated by the Stevenson-Wydler Act, we have established Offices of Research and Technology (ORTAs) at our labs and are active participants in the Federal Laboratory Consortium (FLC). The FLC provides a national network linking laboratories with other Federal entities, State, local, and regional governments, and the private sector. In May 1991, the Phillips Laboratory at Kirtland AFB, NM joined a strategic alliance with the Sandia National Laboratory and the Los Alamos National Laboratory to collaborate on future technical efforts. We have found that the ORTAs and the FLC provide the crucial link in the transition of technology information from the laboratory to other laboratories and the private sector.

As ORTAs provide technology information, so the Cooperative Research and Development Agreements (CRDAs) provide a means of transferring information, providing unique facilities, and gaining technical expertise within our laboratories. Currently, we have several CRDAs in effect and several more in negotiation. Based on our current experience, we expect the number of CRDAs to expand in the future. The CRDAs are meeting their objective of bringing the Air Force laboratories and non-government laboratories together in joint ventures.

We also look to the international community for joint Science and Technology programs. The Air Force maintains offices in the European theater to keep abreast of our allies' research and development advances and coordinate international agreements. The Air Force is arranging for a similar office to be established in Tokyo, Japan. This is in conjunction with the fiscal year 1991 legislation directing OSD to maintain an office in Tokyo.

In addition to our permanent workforce in the Air Force labs, we draw much needed temporary technical expertise from industry and academia with which our Air Force labs have close complementary relationships. With industry, we focus on that R&D which is application-oriented, and can provide a return on investment for both industry and the Air Force. With academia, we focus on long range, basic research. We are able to enhance our technical expertise by utilizing prestigious civilian "visiting" scientists and engineers through programs such as the University Resident Research Program (URRP), Expert-in-Science Program, Summer Faculty Program and the National Research Council Associateship Program. These programs give us the ability to reach into universities in every State, where the capabilities exist, to assure a critical mass of expertise in emerging technologies. In addition to these programs, we also have programs in place to "grow our own" experts. Doctoral-level students are recruited under the Air Force's Palace Knight program, a long-term full-time training program that recruits promising talent and places these individuals at leading universities. Additionally, the Laboratory Graduate Fellowship Program annually awards 25 3-year fellowships for doctoral-level training. This Air Force program provides tuition/fees/stipend and assigns sponsoring laboratory personnel as mentors for the student.

As we look toward the 21st century, we see a greater and more pervasive need for our Air Force laboratories to maintain technical excellence. We are at a threshold where we can foresee technological breakthroughs. For example, the National Aero Space Plane program is demonstrating technologies that could revolutionize aerospace and rival the impact of the jet engine on military capabilities and commercial transportation. That is only one example—there are many others—of how advanced technology will change the way the Air Force operates in the 21st century.

The Air Force sustains the vision of *Global Reach—Global Power*. The Air Force will continue to provide cutting edge capabilities as we invest in advanced technologies and incorporate these technologies to modernize our current force structure. New systems will use the latest technologies to achieve higher reliability and better supportability at lower cost. Our commitment to research and development serves as an investment in the weapons of the future, weapons which will serve our interests tomorrow as admirably as have today's high technology weapons. We will maintain our long-term commitment to support and strengthen the U.S. industrial base. We will also continue to recruit and train the scientists and engineers who will shape the future Air Force.

The 21st century aerospace future is at stake. Our Air Force laboratories are absolutely essential in maintaining U.S. technical superiority. We must plan for the future, not react to it. Your support is crucial.

Thank you, Mr. Chairman, for the opportunity to make this statement. I will be happy to answer your questions.

Senator BINGAMAN. Mr. Adolph, in your statement, you refer to legislation that is working its way through the Department of Defense, do you know when we would receive that?

My concern is that 30 days from now we close the books on what we are going to include in the Defense bill. And if we get that legislation in mid-July or August, it is not going to be that useful for us this year. As you are aware, we legislate once a year around here on defense items and so we need to receive that as soon as possible.

Mr. ADOLPH. Mr. Chairman, I will give you a brief overview of the status, and candidly, I do not hold much hope of getting it over here in the next month. There is a draft package which has been prepared by the members of one of the working groups of the laboratory demonstration project. The legislative working group has prepared the package. It has been coordinated informally at the action officer level within the services in OSD, OMB, and OPM.

The package is now in the first step of the formal coordination processes in our office of General Counsel in OSD. I am going to have a weekly review of the status of that package. I am going to do everything I can to expedite it. But I very candidly do not think we will make it over here in the next month or so.

Senator BINGAMAN. If we do not receive it in the next month, then we have a year delay, which I think is unfortunate. If there was anyway that you could identify and send us the sections of the legislation that are agreed upon within the Department of Defense that would be useful from our perspective.

Mr. ADOLPH. Mr. Chairman, I will make every attempt to do that.

Senator BINGAMAN. That would be a big help. Even after hearing everyone's statement, I am still not clear as to this relationship between the Laboratory Consolidation Commission Report, which I gather will be completed by the end of September, and the Base Closure Commission activities, which are to be presented to the President in the form of recommendations by July 1. How does that relate as you see it?

Mr. ADOLPH. You have addressed the time lines. The Advisory Commission Report is due in to the Secretary on September 30. So, it will not be able to impact the Base Closure Commission Report for this year. It will, however, impact the infrastructure within the framework established by the Base Closure Commission. It will have an impact in that area. And it would potentially have an impact on base closure reports for 1993 and 1995.

But the timing is such that it will not impact this year's report. Genie McBurnett addressed the legislative requirement for the 20 percent drawdown for the base closure report. That has already been signed out by the Secretary. So, fundamentally, it will not impact this year's Base Closure Commission activity.

Senator BINGAMAN. Are you reasonably confident that these recommendations given to the President on July 1 will not contradict what you are trying to accomplish and what the Advisory Commission is likely to come up with?

Mr. ADOLPH. Yes, I am confident of that, because the members of the Advisory Commission are aware of the relative time lines and are well aware of the framework within which they are operating.

Senator BINGAMAN. Let me ask you one other question, Mr. Adolph. I have been concerned that some of our defense laboratories, of particular services are not directed by a civilian and accordingly, we have tremendous turnover in those positions, much faster than in the Department of Energy laboratories, for example. Also, much faster than in any of the private sector laboratories I am aware of on a regular basis.

Does it make sense to try to consistently, across the services, have the civilian laboratory director as the top management official at the laboratory on technical issues? Is that something that we should try to implement throughout the services?

Mr. ADOLPH. I think that the services need some flexibility and I think you have touched on the two dimensions. One is tenure and the other is the technical qualifications of the individual involved. There are instances in the medical areas, as an example, where there are highly qualified individuals who remain in the position for a sufficient length of time, which I would define as a minimum of 4 years.

I think the Navy's approach of having a military commander over the facility and a civilian technical director address the technical activities is a good approach that has a lot of merit. There are differing approaches based on the circumstances within the individual services and within the individual laboratories in the services. Perhaps the service representatives might want to comment on that.

Senator BINGAMAN. I am very concerned about the constant change that takes place in our laboratory systems. I have had more experience with the Air Force labs, but it appears that we are changing the top people at many of our laboratories on a very rapid basis. Do any of you want to comment on that?

General CONDON. Sir, I would be pleased to comment. I come from a laboratory background, having served as a laboratory commander at one point during my career. And I served in a different laboratory where we had a military commander and a civilian deputy at another point in my career.

I think it is important to realize that, at least in the way the Air Force handles this situation, the guidance for the activities in our laboratories does start with a civilian. That guidance comes from Mr. Jack Welch, who is the Assistant Secretary of the Air Force for Acquisition. He issues annually, guidance for the technical program that the laboratories are to execute.

Currently, one of our four super laboratories is directed by a civilian. Historically in the Air Force, we have used what I think is a well-balanced approach, in some cases, with a military commander or director, backed up by a strong civilian deputy. And I think, through that approach, we have been able to infuse new ideas by periodic changes of one of those two top positions, but at the same time, maintain the continuity through the strength, typically, of a civilian deputy, that we need in order to continue an effective program.

That is clearly not the only way that it could be done, but I think, in our case, at least in the Air Force, it has worked extremely well for us.

Senator BINGAMAN. Senator Coats.

Senator COATS. Thank you, Mr. Chairman.

Mrs. McBurnett, you indicated in your statement that it was essential to our Nation to maintain an academic and industrial technology base to assure our ability to counter threats in the future, and I agree with you very much on that statement.

I wonder if you could detail, and maybe Mr. Adolph, you will want to comment on this also, how you are addressing the whole question of fostering that development on the academic and industrial side, what this effort, currently underway, how that might affect that and what specifically we can do to accomplish this objective?

Mrs. **McBurnett**. Yes, sir. Let me comment briefly, and I have Rear Adm. Bill Miller with me who is the Chief of Naval Research, and he may want to add to it.

First of all, part of that fostering starts with our science and technology investment. There, with a very conscious program directed by the Chief of Naval Research, we invest almost half of those funds outside the Navy. Those are very precious funds and very sought after.

So even in the beginning, you can see the importance we place on the university community, which receives a large part of our science and technology budget, as well as industry. It is our full intent to continue that sharing and fostering of both in-house and out-of-house work.

Going beyond science and technology, we now have a very close relationship, a team concept between our Navy program managers, most of whom are here in Washington, our centers or laboratories that are in the field, and their industry counterparts. They frequently work together in terms of both the technical support, and review, and comment back and forth with each other.

It is our full intent to continue that. To keep a very close eye on the share of the work that goes in-house and the share of the work that goes out-of-house, so that we not only foster our in-house capability, but also that capability which resides out-of-house.

Would you like Admiral Miller to expand on that or Mr. Adolph?

Senator **Coats**. Well, I would like to hear from Mr. Adolph in terms of OSD's overall position on the issue.

Mr. **Adolph**. Just briefly, part of the legislative package includes establishment of cooperative programs of State and local governments, private research organizations, and universities. So, we are addressing that dimension in the legislative package.

Senator **Coats**. Well, in terms of the approximate 20 percent downsizing here, of both funds and commitment to these areas, are you looking to upside that on the private side in the academic and industrial community, not necessarily with more transfer of funds, but in terms of establishment of working relationships and coordination of activities, utilization of results and so forth?

Mr. **Adolph**. Let me answer that. A general or philosophical approach that we are using across the board in the cuts, one of the basic tenets in our approach, whether it be in the lab, the T&E, or in any of these downsizings, is to absorb it through increased efficiencies with any infrastructure. And that has to do with part of the consolidation and collocation.

Second, dropping lower priority activities. We are not downsizing and then handing off the work to the private sector or to FFRDC. That is not a part of the plan. That is not being used as an offset for the downsizing, because the downsizing is in the total budget and in the in-house resources. So, we are not trying to off-load the work to the private sector or to academia.

Senator **Coats**. But I assume the objective is to maintain the same level, hopefully, a more efficient level and flow of technological development and research for less dollars.

Mr. **Adolph**. That is correct.

Senator **Coats**. Do any of you see that we are going to jeopardize the flow of sufficient information and research into the proper applications that each of the services ultimately want to get to by this consolidation? In other words, are we just doing this for efficiency purposes to maximize the use of the dollar? Or, have we crossed a line, are we budget forcing crossing a line in which the end product is going to be less than what we currently have?

Mr. **Adolph**. All of these activities are interrelated and we are trying very hard to maintain the quality, while at the same time, downsize. That is why a number of elements are tied together and work through the steering group.

I mentioned that there is an action plan in coordination. Dr. Herzfeld testified on the Defense Critical Technologies Plan a couple of weeks ago. There is a defense technology strategy in which we are trying to prioritize the critical technologies and address them so that in this entire process, we are working in a coordinated manner and not degrading the quality of the research.

Senator **Coats**. That includes the potential of duplication among services in terms of research development and items that would overlap?

Mr. **Adolph**. Yes.

Senator **Coats**. My time has expired, but thank you.

Senator **Bingaman**. Are we to a point where you would be able to give us that set of 28 technology areas and specify which laboratory in the DOD complex, in all of the services being considered, is considered the lead laboratory for DOD in each of those 28?

Mr. **Adolph**. We are trying to get to that point through the reliance activities, and reach final closure across the board. Our target is to do that by the end of 1991. We have reached agreements in some areas and there are no reasons why those agreements cannot be shared with you. I do not have them with me today, but we will certainly get them to you.

There are other areas that are still under negotiation and still under discussion. But our intent is to reach closure by the end of calendar year 1991 in all of the reliance areas across the board, in both the science and technology and the test and evaluation areas.

Senator **Bingaman**. In these science and technology areas, the idea of this reliance initiative is, as I understand it, to insure that you are not duplicating unnecessarily across the different services. Do you have the defense side of the Department of Energy working with you in that reliance initiative? It would seem logical to me that they would participate in that because they have very substantial dollars maintaining core competencies in many of the same technologies that presumably are on your list of the 28.

Mr. **Adolph**. They are not currently actively involved as a part of the working group. When we get into considering new facilities where we have some knowledge of either Energy or NASA interest, we work with the appropriate people to insure that there is not any unnecessary duplication.

Senator **Bingaman**. As I understand it, there is an agreement in the works between the Department of Defense and the Department of Energy, related to joint efforts on critical technologies. I do not know that it has been signed yet.

Mr. **Adolph**. I am not personally familiar with that agreement.

Senator **Bingaman**. Does anyone here have some knowledge about this agreement?

General **CONDON**. Sir, I am not sure that this is related directly to what you refer, but the Phillips Lab at Kirtland has signed a memorandum of agreement with Sandia and with Los Alamos, to share technology information. Now, whether it goes as far as what you just described, I do not know, because I do not know the specifics of that. But the main intent there is to work out a formal agreement where the Phillips Lab and those two national labs can share information, can share technologies, can work joint efforts in a more expeditious manner.

Senator **BINGAMAN**. I am aware of that and I think it is an excellent step, but that strikes me as an agreement. You have a local geographical proximity there and it is very natural that those laboratories would want to work together on areas of joint concern.

If one of the Department of Energy laboratories is preeminent in one of the 28 technologies, could you work together under a joint agreement to decide where to put your resources? The Department of Energy may also want to contract with the Department of Defense for some work.

Mr. **ADOLPH**. That is correct and we need to take that under consideration as a part of the steering group review, and we will definitely do that.

Mr. **SINGLEY**. May I comment, Senator?

Senator **BINGAMAN**. Yes, please.

Mr. **SINGLEY**. The project reliance issue that was raised, we have broken those 28 technology areas into subareas and sub-subareas and pretty much across the board identified, or at least in many cases, a service that will take the lead in that respective area.

We looked into those areas where additional, unique capabilities may be outside of the Department of Defense. I would offer, for example, in the case of rotocraft technology, we are leveraging and have been leveraging for 20 years now, the NASA facilities, where we have our aero structures lab down at Langley Air Force Base, or NASA Langley Research Center Aero Propulsion at NASA-Lewis. And so, that does get factored in as we look at these particular areas.

Senator **BINGAMAN**. The testimony we had last year from Dr. Deutch of MIT, was that in his opinion, if we wanted to maintain world-class laboratories in the services, we really had to do it by contracting out, just as the Department of Energy had. That we had to have government-owned, contractor-operated laboratories if we wanted to have world-class capability for DOD to rely upon.

His recommendation was that we essentially direct each of the services to pick a laboratory and make it a government-owned, contractor-operated laboratory over a period of years. When asked about Dr. Deutch's recommendation, the Department of Defense officials were not enthusiastic.

I would be interested in any comments that any of you might have.

Mr. **ADOLPH**. First of all, the operation is being reviewed by the Advisory Commission. They will review that recommendation and comment on it. I do not know whether the services care to make some comment.

Senator **BINGAMAN**. Also some of the services such as Lincoln Lab have that arrangement. It is also my understanding that the

Air Force sponsored GOCO. Do any of you have comments as to whether more movement in that direction makes sense over the long term as we look to maintain our technology base.

General **Condon**. The only comment that I would make is that, if the assertion is that contracting out is the only way to maintain world-class laboratories, then I guess I would take issue with that assertion. I think that the laboratories in all of the services have, in specific fields, demonstrated their world class status.

Clearly, as Mr. Adolph has mentioned, the GOCO approach will be considered by the Commission that is doing its work right now. And so, it should not be ruled out just out of hand.

But, I believe that as we look at the linkages that are required between the operational forces in each of our services, the linkages between those operational forces and our technology efforts, it is extremely important that we not lose that direct connection between the customers that we are trying to serve and the technologists in our service laboratories who are trying to provide the technologies needed for that war fighting capability.

I guess my comment would be, I think that we can maintain world-class caliber laboratories with our respective service laboratories, without going to a GOCO approach.

Senator **Bingaman**. I know you have each recited initiatives, reforms, and improvements that are occurring, many of them administrative, with the use of credit cards and various things that are saving money.

I am unclear as to whether we have a good indication of which of these initiatives are being applied broadly or are intended to be applied broadly to all of the defense-related labs. And which ones are intended to make up a demonstration program which we would have to test for some period, presumably before we decide whether to apply it broadly?

Mr. Adolph, I believe a lot of the things that people testify to here, sound as if they are not appropriate for any kind of demonstration program. They are really just good management and they should be applied everywhere as quickly as you can implement the new procedures.

Is there a way to sort out what you can apply broadly and what you have to do on a demonstration basis because you do not know whether it is going to work?

Mr. **Adolph**. Certainly, all of the initiatives that you indicated fall into the area of good management procedures, such as giving the laboratory directors increased flexibility in the contracting area, or getting rid of some of the bureaucratic impediments. They need to go to the entire laboratory structure and I would even go one step further to the entire science and technology support, whether it be laboratory acquisition or test and evaluation.

But there are some issues, for legislative reasons or purely because of the fact that they are not yet proven in a wide variety of environments, that need to be kept a part of a demonstration program. I would include in that area, issues such as pay banding and classification by delegation of some of the classification authority from the personnel shop to the engineers and scientists. I think those concepts have shown that they have merit in a relatively limited environment and they need to be expanded somewhat.

But I think that approach needs to be kept within a small demonstration environment and we need to insure that it does, indeed, have merit before we, even if we are allowed to, go across the infrastructure. There are some issues of baselining and accounting that need to be worked out before we would attempt to apply those across the board.

Senator **Bingaman**. One set of management practices that would seem to be appropriate for broad application are the kinds of pay arrangements they have at China Lake. We have been talking about that ever since I came to town 8 or 9 years ago and to my knowledge, it still has not been generally implemented elsewhere.

Is there a reason why we cannot just go ahead and do that in the Federal laboratory system nationwide?

Mr. **Adolph**. The Office of Personnel Management will only allow a limited number of demonstration programs at a limited number of facilities. So, we do not have the prerogative within the Department of going out and doing that. We have to get permission from OPM. We are seeking, as a part of the legislative package, to increase that authority to all of the demonstration laboratories.

I am familiar with that project and I think there is enough uncertainty having been personally involved in applying some of the dimensions to an Air Force installation. I think there are enough unknowns in terms of its general applicability across the board, that we would want to continue to keep it on a demonstration level. And we are seeking to do that for all the demonstration laboratories.

Senator **Bingaman**. My concern is that these demonstrations are going to outlast me. I am not sure how long the people in New Mexico are going to keep sending me here. If in fact, what they are doing at China Lake makes sense, let's go ahead and proliferate it throughout the defense lab system. If it is not working, shut it down at China Lake. If it is working, let us do it elsewhere as well.

When can we make that decision, in your opinion?

Mr. **Adolph**. In my opinion, the first step is to broaden the demonstration base. That needs to be done and we need to try it for a few years. What works at China Lake may or may not work in other environments.

Senator **Bingaman**. What is required to broaden that demonstration base?

Mr. **Adolph**. What we need to do is get the legislative package over here and get it approved.

Senator **Bingaman**. Will we have to legislate to get that done? The Office of Personnel Management cannot authorize that?

Mr. **Adolph**. We are getting into some details I am not totally conversant with. But they have allowed in the past a number of demonstration programs with a cap on the maximum number. So, we need, as a part of this package, to expand it to include the laboratories in the Laboratory Demonstration Program. They have not, in the past, allowed additional demonstration programs of that type.

Senator **Bingaman**. Could we include a provision in the law, if it is not already there, stating, any demonstration program approved by Office of Personnel Management at a Federal laboratory is fully authorized by the Congress, so that nobody can come back and say, no, no, we need legislation?

Our problem is, we have so many different entities in this game that everybody can say, no, no, the Congress has got to act first. OPM has to act, or one of the services has to act. Everybody is pointing at everybody.

What if we just got out of the circle here in Congress by authorizing OPM to approve any demonstration program they wanted to, consistent with what is happening at China Lake?

Mr. ADOLPH. I do not know how to respond to that one, because I do not know all the implications. I do know that I personally have tried very hard in the past, to expand that concept to a couple of Air Force installations and we were not allowed to transfer it because of the cap at the time on the number of demonstration programs. Now, I think what you are suggesting, fundamentally is, that we raise that cap.

Senator BINGAMAN. I am saying, eliminate it, not raise it. I am saying, just eliminate the cap and leave it up to OPM to decide when some of these procedures should be applied across the services.

Mr. ADOLPH. From my perspective and based on my understanding, that sounds like a good idea. We certainly need more flexibility to try a variety of things in a variety of areas and we have been far too constrained in the past.

But I would put a footnote in again. If you combine pay banding with manage to payroll, the net effect of that will be downsizing.

Senator BINGAMAN. Is this not the right time to do that? We are going through a reorganization at this point and instead of going through a reorganization and then coming back in 5 years and saying, okay, now we are going to downsize everything, would it not be better to do that simultaneously?

Mr. ADOLPH. To the extent that we can, yes. But these initiatives, the pay banding, the classification initiatives, the contracting initiatives, will all have utility and be applicable regardless of how we downsize the infrastructure.

Senator BINGAMAN. Maybe we can visit with you in the next few weeks about what a provision might look like, because I am anxious that we get off of the isolated demonstration idea and get on with some broad improvements in the way we manage the labs. And I think the consolidation that is occurring in each of the services is very useful and constructive efforts in getting that done. And I would just like to be sure that while we are doing that, we also implement as much of the rest of this as we can.

Mr. ADOLPH. We will follow up and get back with you.

Senator BINGAMAN. Is it possible to identify and prioritize the critical technologies in the Defense Critical Technologies Plan most important to the Department of Defense laboratory system?

Mr. ADOLPH. Well, I think our thrust right now is through the technology strategy, to prioritize areas of investments in the near term and in the far term, areas that will have the largest potential impact in the weapons systems in the next 10 years or so. So, prioritize for investment purposes in the strategy.

And then prioritize within the action plan, which is really the implementation plan, the do-outs, if you will, of all the activities, the reliance activities in the investment inputs. That is the current thrust in the Department.

Senator **Bingaman**. It would seem that the next logical step, if you are going to try to allocate funds in the most intelligent way is to identify an area of technology that is strong, such as photonics. If we want to maximize our competence in this technology area, let us see where we are strongest in photonics technology development in the service laboratories so that we can, at least as an initial matter, consider putting whatever additional resources we have into strengthening that effort so that they are not begging for money while we are out trying to start a new laboratory somewhere.

Mr. **Adolph**. That is one of the fundamental ideas behind the reliance process, to identify areas of strength and to identify lead areas. Where we have areas of coordination among three services, move and select a lead service or develop a memoranda of agreement so that there will be a lead and so that we do play to the strengths in a given area within the service infrastructure. In the future our capital investments in upgrades or new research will go to those areas that are defined as leads.

Senator **Bingaman**. For example, when would we be able to pick one of these technology areas or a subset under it, composites, ceramics, photonics and get an agreement from the services that our strength is in this particular area?

Mr. **Adolph**. Those agreements have been reached in some areas already.

Senator **Bingaman**. Do you think there is a consensus?

Mr. **Adolph**. There is a consensus in some areas and there are still some differences in other areas. But by the end of this year, all the reliance areas across S&T and T&E, we will have reached agreement.

Senator **Bingaman**. Could you advise us, for the record, as to those areas that you do have some agreement in already?

Mr. **Adolph**. Yes. We will submit that.

[The information follows:]

Areas of Agreement

Let me qualify what we mean by agreement. In the S&T, there are a total of 28 areas which are covered under inter-service reliance agreements. These areas have all been agreed to by the three services, mechanisms for overseeing inter-service coordination have been established and are operational, and the services are now working to develop joint program plans. We at the OSD level are working to incorporate these new planning procedures into our management process. Our goal is to plan the fiscal year 1993 program under the framework provided by the reliance agreements. The specific areas of agreement are: aeropropulsion; air vehicles (fixed); air vehicles (rotary); astrometry; chemical and biological defense; civil engineering; clothing, textiles and food; communications, command and control; conventional air/surface weaponry; electro-optics; electronic devices; electronic warfare; environmental quality; environmental sciences; explosive ordnance disposal; fuels and lubes; ground vehicles; integrated avionics; manpower and personnel; medical; nuclear weapons effects; radar; ships/watercraft; small arms; software; space; training systems; and unmanned ground vehicles. As you are well aware, we have already had working agreements in explosive ordnance disposal, chemical/biological defense, and medical technology. In T&E, the military departments have reached agreement through Project Reliance in the areas of chemical weapons/chemical and biological defense and land vehicles. In these two areas they designated the Army as lead service.

Senator BINGAMAN. As others are agreed upon, please keep us informed.

We will have some other questions for the record that I will not keep everybody for today. I think this is useful and I have got to say, I am encouraged by the amount of effort that I think is going forward in all the services and the Department, to streamline and to make more efficient our laboratory system.

I do think there is a lot of good thinking going on, a lot of good planning, and I think the consolidation effort is going to pay off for the services and for the country. I am encouraged by that.

If any of you have anything else, we will hear it now. Otherwise, we will adjourn the subcommittee. [No response.]

Senator BINGAMAN. Thank you all very much.

[Questions for the record with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR JEFF BINGAMAN

DOD IN-HOUSE LABS

Senator BINGAMAN. Mr. Singley, Mrs. McBurnett, and General Condon, in determining laboratory closings, consolidations and realignments, were assessments made of the impact of these planned actions on research being performed in these laboratories related to environmental compliance, waste minimization, and environmental restoration and remediation activities? Please describe the impact on environmentally related or driven research on a laboratory-by-laboratory basis relative to those being closed, realigned, or consolidated.

Mr. SINGLEY. The following Army laboratories conduct research in support of the Army's environmental compliance, waste minimization, and environmental restoration and remediation programs:

a. Waterways Experiment Station (Corps of Engineers).
b. Construction Engineering Research Laboratory (Corps of Engineers).
c. Biomedical Research and Development Laboratory (Surgeon General).

The Biomedical Research and Development Laboratory (BRDL) is the only laboratory affected by DOD laboratory consolidation supporting these areas of interest. BRDL is planned to be closed and the Health Effects Research Division of BRDL would be collocated with the Air Force Toxicology Laboratory, Wright Patterson Air Force Base, Ohio. The work done by BRDL provides environmental health effects and contaminant fate data required to determine safe cleanup levels at contaminated Army and DOD sites and safe discharge levels for Army industrial facilities. BRDL's research is executed for the Corps of Engineers (COE), which has the overall environmental quality mission in support of the Department of the Army. The products of this research are an integral part of the total COE program.

There will be short term impacts and costs to collocate BRDL at Wright Patterson AFB. The long term benefits for DOD technology should outweigh the impacts and costs of collocation. Every effort will be made to minimize these impacts and costs.

Mrs. MCBURNETT. The Navy laboratory/center consolidation plan includes a major restructuring of mission and leadership areas among the 36 activities affected. This restructuring was based on an assessment of the functions being performed by each of the existing activities, and which of these functions would benefit from consolidation with other functions, transfer to another activity or site, or other realignment action. The R&D work currently being performed in the areas of waste management and environmental compliance and remediation was included in this assessment. Although a number of Navy, commercial, and non-profit activities participate in this effort, the largest single performer is the David Taylor Research Center (DTRC), Annapolis Detachment, Maryland.

Under the Navy laboratory/center consolidation plan, DTRC and several of the other activities involved in environmental R&D programs will be consolidated into the Naval Surface Warfare Center (NSWC). The Navy plan does not require Navy program managers to direct their funding to specific labs/centers, but does outline broad leadership areas for each consolidated lab/center. Program managers have been instructed to adhere to these leadership areas when choosing a Navy lab/center to execute part of their program. Since the consolidation effort will require 5 years to complete, interim procedures may be necessary, especially in cases where a leadership area is being transferred from one activity or site to another. These interim procedures are the subject of ongoing discussions among the labs/centers, the Systems Commands, and individual program managers. These discussions have not been completed, so no data are available on the future distribution of environmental R&D funding among the various activities currently participating in these efforts.

The consolidated NSWC will continue to retain leadership for the area of environmental and waste management R&D. There are no plans to reduce funding for this important area, and no changes to planned efforts are expected as a result of the consolidation of Navy labs and centers. However, the program managers responsible for the investment of these funds are ultimately responsible for choosing the best performer for each task, and there is no assurance that funding levels at each existing lab/center will continue at their present levels.

General **CONDON**. For the Air Force, there is no impact on the environmental research activities. Environmental technology research is performed at a research complex at the Air Force Engineering and Services Center, located at Tyndall AFB, FL. This research complex will continue to perform Air Force-unique research in many environmental areas, including restoration, waste minimization and compliance. Under the Tri-Service Project Reliance effort, the services have reached cooperative program agreements for research efforts, thus preventing duplicative efforts. Results of these research efforts will be shared among the services.

LABORATORY CONSOLIDATION (HOUSE AND SERVICES COMMITTEE)

Senator **BINGAMAN**. Has any written guidance been given to the Advisory Commission on Laboratory Consolidation and Closure that would preclude it providing recommendations or advice to the Base Realignment and Closure Commission? If so, please provide the subcommittee with copies of any such guidance.

Mr. **ADOLPH**. Subsequent to the hearing, a legal opinion was requested by and provided to the Commission (attached).

DEPARTMENT OF DEFENSE,
OFFICE OF GENERAL COUNSEL,
Washington, DC., June 14, 1991.

MEMORANDUM FOR CHAIRMAN, COMMISSION ON THE CONSOLIDATION AND CONVERSION OF DEFENSE RESEARCH AND DEVELOPMENT LABORATORIES

SUBJECT: Authority of the Commission

This is in response to your request for my opinion as to whether it would be appropriate for the Commission on the Consolidation and Conversion of Defense Research and Development Laboratories (hereafter "laboratory commission") to provide its views now to the Defense Base Closure and Realignment Commission (hereafter "base closure commission") on the question of whether the latter commission should consider the laboratories.

Section 246 of the National Defense Authorization Act for Fiscal Year 1991, Pub. L. No. 101-510, established the laboratory commission as an advisory committee under the Federal Advisory Committee Act to provide its recommendations to the Secretary of Defense. As an advisory committee, the laboratory commission has no independent authority to act beyond the scope of its charter, that is, the statute and the charter filed with the General Services Administration. There is no provision in the statute or the charter for the laboratory commission to submit its advice or recommendations to any person or entity other than the Secretary of Defense

You also asked whether it would be permissible for the laboratory commission to provide its preliminary views to the Secretary of Defense on the laboratories being considered by the Base Closure Commission. There is no legal objection to the laboratory commission providing its preliminary views on matters within the jurisdiction of the commission to the Secretary of Defense.

GURDEN E. DRAKE.

DOD IN-HOUSE LABS

Senator **BINGAMAN**. Mr. Singley, Mrs. McBurnett, and General Condon, please provide the subcommittee with the Defense Department's current best estimates, on an individual military service basis, of anticipated costs for fiscal years 1992 through 1994 to accomplish the planned in-house laboratory consolidations, closures, and realignments.

Mr. SINGLEY. The Army's current best estimate of anticipated costs to accomplish in-house laboratory consolidations, closures, and realignments are the estimates from the Cost of Base Realignment Action (COBRA) model. They are:

[Dollars in thousands]

	Fiscal year 1992	Fiscal year 1993	Fiscal year 1994
Personnel	$8,627	$3,530	$2,689
MILCON/Equipment	27,490	20,748	42,992

Mrs. MCBURNETT. A summary of anticipated costs for fiscal years 1992 through 1994 has been derived from the Cost of Base Realignment Actions (COBRA) model.[1] Using model estimates for the 36 laboratories and centers considered for closure, realignment or consolidation, the anticipated costs for fiscal years 1992 through 1994 (in fiscal year 1992 constant dollars) are:

Fiscal year:	*Millions*
1992	$ 86.2
1993	91.7
1994	136.2

General CONDON. The Air Force is in the process of identifying detailed costs associated with the proposed physical consolidation of geographically-separated directorates. These costs will be included in the economic analysis section of the Air Force Plan of Consolidation that is currently being developed. The Air Force is scheduled to complete the Plan in the fall of 1991.

Senator BINGAMAN. Mr. Singley, Mrs. McBurnett, and General Condon, please provide the subcommittee with the Defense Department's current best estimates, on an individual military service basis, of anticipated savings of the next 10 fiscal years to be achieved through the planned in-house laboratory consolidations, closures, and realignments.

Mr. SINGLEY. Tne Army's current best estimate of anticipated savings to be achieved through the planned in-house laboratory consolidations, closures, and realignments over the next 10 fiscal years are the estimates from the Cost of Base Realignment Action (COBRA) model. They are:

[Dollars in thousands]

	Fiscal year 1992	Fiscal year 1993	Fiscal year 1994	Fiscal year 1995	Fiscal year 1996	Fiscal year 1997	Beyond
Personnel	$6,700	$15,700	$19,925	$33,500	$46,800	$48,450	$48,450
Overhead					3,000	3,000	3,000
Funded MCA	5,000	10,000					
BRAC I	10,000	50,000	17,000				
Land Sale						11,000	

The savings associated with the consolidations were already taken by DMRD 922, and the Army's budget was previously reduced.

Mrs. MCBURNETT. A summary of anticipated savings for fiscal years 1992 through 2001 has been derived from the Cost of Base Realignment Actions (COBRA) model.[2]

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[1] NOTE: COBRA cost estimates include one-time and recurring costs using both standard factors and site-specific data. The COBRA model estimates provide useful management information on the relative costs associated with various closure or realignment scenarios, however, the COBRA output is not intended for use in preparing detailed budgets.

[2] NOTE: COBRA model estimates include one-time and recurring costs using both standard factors and site-specific date. The COBRA model estimates provide useful management information on the relative costs associated with various closure or realignment scenarios, however, the COBRA model output is not intended for use in preparing detailed budgets.

Using model estimates for the 36 laboratories and centers considered for closure, realignment or consolidation, the COBRA model calculates savings through fiscal year 1997 and provides an estimated annual savings to be achieved in fiscal year 1998 and beyond. With this in mind, the anticipated savings in fiscal years 1992 through 2001 (in fiscal year 1992 constant dollars) are:

Fiscal year:	*Millions*
1992	$ 20.8
1993	34.2
1994	79.9
1995	168.9
1996	142.8
1997	138.6
1998	137.2
1999	137.2
2000	137.2
2001	137.2

General CONDON. The Air Force is in the process of doing a Plan of Consolidation that includes economic analyses that describe costs and benefits for consolidation. The Air Force is scheduled to complete the Plan in the fall of 1991.

CORE COMPETENCIES

Senator BINGAMAN. Mr. Adolph please provide for the record the Defense Department's assessment of where core competencies exist within the in-house lab structure in advancing the national science and technology agenda.

Mr. ADOLPH.

Army

DCSPER

Research Institute for Behavioral & Social Sciences
    Selection, Assessment, Psychometrics, Training

Corps of Engineers

Cold Regions Research and Engineering Laboratory
    Impact of Cold Temperatures on Material Operations
    Sustainment
Construction Engineering Research Laboratory
    Facilities
    Environmental Restoration & Impact
    Energy Management
Engineer Topographic Laboratories
    Digital Mapping
    Geodesy, Photointerpetation
    Position Navigation
    Remote Sensing
Engineer Waterways Experiment Station
    Hydraulics
    Hardened Structures
    Hydrology
    Terrain & Mobility
    Coastal Engineering
Institute for Water Resources
    Water Supplies
    Engineering Economics
Hydrologic Engineering Center
    Hydrologic Engineering
    Flood Damage Assessment

U.S. Army Medical Research & Development Command

Aeromedical Research Laboratory
    Aviation Systems Hazards
Medical Research Institute of Chemical Defense
    Medical Countermeasures to Chemical Warfare
Institute of Dental Research
    Computer-Assisted Postmortem Identification, Combat Maxillofacial Injuries
Institute of Surgical Research

  - Burns & Trauma
- Letterman Army Institute of Research
  - Blood, Impact of Lasers on Eyes
- Biomedical Research & Development Laboratory
  - Medical Material
- Medical Research Institute of Infectious Diseases
  - Medical Defense Against Biological Agents, Vaccines
- Medical Research Institute of Environmental Medicine
  - Environmental Medicine (Heat, Cold & High Altitude Effects on Soldier Performance)
- Walter Reed Army Institute of Research
  - Infectious Diseases, Combat Stress, Soldier Performance

Information Systems Command

- Army Institute for Research in Management Information, Communication & Computer Sciences (AIRMICS)
  - Computer Software
  - Networks

U.S. Army Materiel Command

- Armament Research, Development & Engineering Center
  - Armor-Antiarmor including Electric Guns
  - Ammunition Production Base
  - Large Caliber Guns
  - Small Arms
- Chemical Research, Development & Engineering Center
  - Chemical & Biological Warfare Defense
- Aviation Research, Development & Engineering Center
  - Aeroflightdynamics of Rotorcraft
  - Propulsion of Rotorcraft
  - Aerostructures of Rotorcraft
  - Systems Integration of Rotorcraft
  - Avionics of Rotorcraft
- Communications-Electronic Research, Development & Engineering Center
  - Command Control & Communications System
  - Tactical Data Networks
  - Electronic Warfare/Reconnaissance, Surveillance & Target Acquisition
  - Software Engineering
  - Night Vision & Electro-Optics
  - Signals Warfare
- Missile Research, Development & Engineering Center
  - Surface-to-Surface & Surface-to-Air Missiles and Rockets
  - Air Defense Target Acquisition, and Control
- Tank-Automotive Research, Development & Engineering Center
  - Ground Vehicle Systems Integration
  - Propulsion and Structures
- Belvoir Research, Development & Engineering Center
  - Countermobility & Countermine
  - Physical Security
  - Environmental Conditioning
  - Fuels & Lubricants
- Natick Research, Development & Engineering Center
  - Food & Nutrition
  - Clothing & Equipment
  - Airdrop
- Atmospheric Sciences Laboratory
  - Atmospheric Effects on Weapons Systems
  - Micrometeorology
- Ballistic Research Laboratory
  - Ballistics
  - Electrically Energized & Liquid Propellant Guns
- Electronics Technology & Devices Laboratory
  - Microcircuitry
  - Optoelectronics
- Harry Diamond Laboratory
  - High Power Microwaves
  - Electronic Fuzing
  - Nuclear Survivability

Radar
Human Engineering Laboratory
    Human Factors
    Robotics
Materials Technology Laboratory
    Metals & Ceramics
    Composites
Vulnerability Assessment Laboratory
    Weapons Countermeasures

Navy

Navy Research, Development, Test and Evaluation Activities
Aerospace Medical Research Laboratory, Pensacola, FL
    Biomedical, Physiological and Behavioral Studies and Effects of Aviation
Air Development Center, Warminister, PA
    Air-borne Surveillance (of submarines, ships, and air vehicles)
    Air Vehicles
    Structures and Materials
    Navigation
Air Propulsion Center, Trenton, NJ
    Air-Breathing Propulsion Systems
    Aircraft Accessories, Components, Fuels and Lubricants
Air Test Center, Patuxent River, MD
    Aircraft Weapons Systems Life Cycle Support
    Full-Scale Development, Production and Fleet In-Service
    Engineering Support
Atlantic Fleet Weapons Training Facility, Roosevelt Roads, P.R.
    RDT&E Training Facilities and Services
Biodynamics Laboratory, New Orleans, LA
    Human Neurophysiology Effects
    Biodynamic Stress, Anthropomorphic Manikins Studies
Biosciences Laboratory, NSC Oakland, CA
    Immune Mechanisms
    Microorganisms
    DNA Technology
    Effects of Organometallic Compounds
Civil Engineering Laboratory, Port Hueneme, CA
    Fixed Surface and Subsurface Ocean Facilities
Clothing & Textile Research Facility, Natick, MA
    Clothing Textiles
    Environmental Protective Clothing
Coastal Systems Center, Panama City, FL
    Mines Countermeasures
    Special Warfare
    Torpedo Defense
David Taylor Ship R&D Center, Bethesda, MD
    Surface Ship and Submarines
    Ship Materials
Dental Research Institute, NTC Great Lakes, IL
    Dentistry and Allied Sciences
Environmental Prediction Research Facilities, Monterey, CA
    Regional and Global Environmental Analysis and Prediction Techniques
    Planning and Modeling and Evaluation of Environmental Elements
Explosive Ordnance Disposal Tech. Center, Indian Head, MD
    Conventional, Terrorist, Biological, Chemical, Underwater Guided Missile and
    Nuclear Devices Countermeasures and Safety Procedures
Health Research Center, San Diego, CA
    Biomedical and Psychological Effects on Personnel
Medical Research Institute, Bethesda, MD
    Basic and Applied R&D on Health Safety
Medical Research Unit No. 2, Manila, Philippines
    Diagnosis and Treatment of Infectious Diseases
Medical Research Unit No. 3, Cairo, Egypt
    Diagnosis and Treatment of Infectious Diseases
Research Laboratory, Washington, DC
    Space Technology

- Electronic Warfare
- Electronic Devices
- Radar
- Bio-technology
- Computers
- Oceanography

Ocean R&D Activity, Bay St. Louis, MS
- Ocean Acoustic Technology
- Environmental Acoustics
- Arctic Acoustics
- Physical, Biological/Chemical, and Polar Oceanography

Oceans Systems Center, San Diego, CA
- Micro-Electronics
- Communications
- Command and Control
- Ocean Surveillance

Office of Naval Research and Technology, Arlington, VA
- Basic Research
- Exploratory Development

Ordnance Missile Test Center, White Sands Missile Range, NM
- Test and Evaluation of Guided Missile
- Rocket, Gun and Directed Energy Programs

Pacific Missile Test Center, Point Mugu, CA
- Test and Evaluation of Engineering, Logistical and Training
- Support for Weapons Systems

Personnel R&D Center, San Diego, CA
- Manpower Management
- Education and Training
- Personnel Administration
- Organizational Structures and Management
- Human Factors

Submarine Medical Research Laboratory, Groton, CT
- Medical R&D on Submarines
- Diving and Amphibious Environments

Surface Warfare Center, Dahlgren, VA
- Explosives and Warheads
- Mines
- Composite Materials
- Surface-Launched Weaponry
- Surface Ship Combat Systems

Atlantic Undersea T&E Center, Andros Island, Bahamas
- Underwater Acoustics Measurements
- Testing, Calibration Sonars
- Surface and In-Air Tracking Data on Ships, Submarines
- Aircraft and Weapons

Underwater Systems Center, Newport, RI
- Ship and Submarine ASW
- Combat Control
- Torpedoes

Weapons Center, China Lake, CA
- Surface and Air-Launched Guided Missiles and Weaponry
- Aerosystems (Parachutes)

Weapons Evaluation Facility, Albuquerque, NM
- Nuclear Weapons Systems Safety

Air Force

Air Force Research, Development, Test and Evaluation Activities

Wright Laboratory, Wright-Patterson AFB, Dayton, OH
- Air Vehicle Technology including Flight Dynamics
- Avionics
- Cockpits
- Aero Propulsion and Power
- Armaments
- Materials
- Solid State Electronics
- Manufacturing Technology

Rome Laboratory, Griffiss AFB, Rome, NY
    Air-borne Command, Control, Communications and Intelligence
    Sensor Systems
    Information Processing
    Surveillance
    Intelligence
    Embedded Processors
    Electromagnetics
    Photonics
    Software Producibility
    Superconductivity
Armstrong Laboratory, Brooks AFB, San Antonio, TX
    Aerospace Medicine
    Crew Systems
    Human Resources
    Occupational and Environmental Health
Phillips Laboratory, Kirtland AFB, Albuquerque, NM
    Geophysics and Directed Energy Weapon Technology Spacecraft
    Structures
    Sensors
    Dynamics
    Rocket Propulsion
    On-Orbit Control
    Orbital Transfer Vehicles
    Space Control
    Space Launch Vehicles
    Lasers and Imaging
Engineering and Service Center, Tyndall AFB, FL
    Civil Engineering
    Environmental Quality R&D

Defense Nuclear Agency

Research, Development, Test and Evaluation Activities

Armed Forces Radiobiology Research Institute, Bethesda, MD
    Biology of Ionizing Radiation

LEGISLATIVE PROPOSAL

Senator BINGAMAN. Please provide for the record the Defense Department's current best estimate of when the legislative package being developed under the Laboratory Demonstration Program will be available for congressional review?

Mr. ADOLPH. The legislative package was forwarded to Congress for review on July 1, 1991.

LEAD LABORATORY ASSIGNMENTS

Senator BINGAMAN. Will the Defense Department provide the Armed Services Committees of the Senate and House of Representatives with their lead laboratory assignments for identified Defense Critical Technologies when final internal determinations on each assignment is reached? Please provide the Department's current planned milestone date for completing this assessment and assignment process.

Mr. ADOLPH. Let me clarify one point. We have been talking about both Inter-service reliance and Defense critical technologies, and I want to make sure that we do not confuse the two. That may be easy to do because our management objectives under Reliance and your objectives under critical technologies are similar: strengthening the DOD S&T program, avoiding duplication, collocating effort where appropriate, establishing world-class institutions, etc. But the technology areas under DOD critical technologies and Reliance do not align directly and most areas are too broad to assign leadership to single services. The fiscal year 1991 Critical Technology Plan contains 21 technologies while Reliance covers 28 areas. Some of the areas are nearly identical—software and electro-optics for example. But Reliance also covers areas which are not on the critical technologies list such as civil engineering and clothing, textiles and food—areas which are core functions of DOD and are of an enduring nature, as compared to a critical technology such as superconductivity, which may or may not be on the critical technologies list 10 years from now. In other words, the Reliance categories are somewhat broader than the critical technologies.

What we are trying to implement is a management structure which is more aligned with the total responsibilities of DOD and accordingly will have more permanence as a management system. I have already outlined the 28 areas in which we have tri-service agreement and are proceeding with implementation plans. The 28 areas are divided into sub-areas and in some cases sub-sub-areas in order to establish service and laboratory leads. While we are not specifically working to establish leads for the critical technologies, Reliance will automatically accomplish most of that. I think before you could see and understand the full impact of Reliance we need to develop the fiscal year 1993 program under the Reliance agreements and then present that package to you. In sum I think we are doing exactly what you want, but the categories may not make it obvious.

NATIONAL LABORATORIES

Senator **Bingaman**. What is the Defense Department's plan to work with the Department of Energy laboratories to include those laboratory capabilities under Project Reliance.

Mr. **Adolph**. We are actively working that issue. Each of the Reliance panels under the Joint Directors of Laboratories has been chartered to include among its functions integrating the DOE labs and programs into the coordination and joint-planning process.

CHINA LAKE EXPERIMENT

Senator **Bingaman**. Mr. Adolph, does the Defense Department believe that there are rationale for not immediately expanding the so-called "China Lake" personnel management experiment to cover all in-house laboratories? If so, please provide the subcommittee with a comprehensive discussion of these reasons for the record. In a similar vein, is the Defense Department aware of any impediments that the Office of Personnel Management might raise in expanding this personnel management practice to all DOD laboratories, and if so, what are they.

Mr. **Adolph**. Reasons for not expanding the Navy's personnel management experiment to cover all in-house DOD laboratories have not been resolved. However, DOD and OPM are currently considering matters related to legality, classification, fragmentation of the civil service system, costs, and other policy issues. As an interim measure, the Department is currently seeking, through proposed legislation, to only expand the program to the 30 demonstration laboratories.

[Additional prepared material for the hearing record follows:]

DEPARTMENT OF THE NAVY
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20350-1000

12 April 1991

MEMORANDUM FOR THE CHIEF OF NAVAL OPERATIONS
COMMANDANT OF THE MARINE CORPS
ASSISTANT SECRETARY OF THE NAVY (RESEARCH, DEVELOPMENT AND ACQUISITION)
ASSISTANT SECRETARY OF THE NAVY (FINANCIAL MANAGEMENT)
ASSISTANT SECRETARY OF THE NAVY (INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (MANPOWER AND RESERVE AFFAIRS)
GENERAL COUNSEL
COMMANDER, NAVAL SEA SYSTEMS COMMAND
COMMANDER, NAVAL AIR SYSTEMS COMMAND
COMMANDER, SPACE AND NAVAL WARFARE SYSTEMS COMMAND
CHIEF OF NAVAL RESEARCH
COMMANDING GENERAL, MARINE CORPS RESEARCH, DEVELOPMENT AND ACQUISITION COMMAND

Subj: RESEARCH, DEVELOPMENT, TEST AND EVALUATION, ENGINEERING AND FLEET SUPPORT ACTIVITIES CONSOLIDATION

Ref: (a) SECNAV Memo 14 Dec 90; same subject

Encl: (1) RDT&E, Engineering and Fleet Suport Activities Consolidation Plan

By reference (a), I supported a concept to consolidate Navy Research, Development, Test and Evaluation (RDT&E), Engineering and Fleet Support facilities. This concept was developed by the Assistant Secretary of the Navy (Research, Development and Acquisition) (ASN(RD&A)). At that time, I tasked the ASN(RD&A), the Systems Command (SYSCOM) Commanders and the Chief of Naval Research (CNR) to develop, in conjunction with the Vice Chief of Naval Operations (VCNO) and the Assistant Commandant of the Marine Corps (ACMC), a detailed consolidation implementation plan and to establish an Executive Review Group to address broad consolidation policy issues. I have reviewed that implementation plan, provided as enclosure (1), and I approve it.

Recent Congressional actions not only reduce the overall Navy budget but also mandate a substantial reduction in the Acquisition Workforce. These actions have expanded the nature of this consolidation from an effort to streamline our infrastructure, to an effort to preserve core mission capability in the face of these reductions.

The Secretary of Defense has forwarded base closure and realignment actions associated with the consolidation plan to the Defense Base Closure and Realignment Commission. We cannot implement any base closure or realignment actions at these installations until they become final under the 1991 base closure and realignment process.

Using enclosure (1) as guidance, I direct that, subject to the provisions of the Base Closure and Realignment Act, the following actions be taken to consolidate Navy RDT&E, Engineering and Fleet Support activities:

- Streamline the Navy Corporate Laboratory structure to a single field activity entitled Naval Research Laboratory reporting to the CNR by 1 October 1991.

- Establish the following Centers by 1 October 1991:

  - o Naval Air Warfare Center reporting to the Commander, Naval Air Systems Command.

  - o Naval Surface Warfare Center reporting to the Commander, Naval Sea Systems Command

  - o Naval Undersea Warfare Center reporting to the Commander, Naval Sea Systems Command

  - o Naval Command, Control and Ocean Surveillance Center reporting to the Commander, Space and Naval Warfare Systems Command

- SYSCOM Commanders, CNR, and the Comptroller of the Navy take all administrative steps required to transfer the claimancy for activities comprising the Corporate Laboratory and those Centers listed in enclosure (1), to the appropriate parent command as soon as possible.

- Effective on the date claimancy transfers are complete, the Office of the Director of Navy Laboratories, to which the seven existing Research and Development (R&D) centers presently report, will be disestablished.

- Effective 1 October 1991, program managers tasking in-house Navy activities with new work or additional work as part of an ongoing effort will direct all such work to the cognizant activity assigned that leadership area as shown in enclosure (1). When Center and Corporate Laboratory assigned leadership areas present conflicts for placement of work, the SYSCOM Commanders and the CNR together will work to resolve the placement issue. Recognizing that there will be a period of time when some cognizant activities will not be capable of performing work in one or more of their specific leadership areas, the SYSCOM Commanders and CNR are to review all such work and develop a plan for the orderly transition of functions from their existing sites to the cognizant activity, as well as addressing a process for assigning such work in the interim.

- SYSCOM Commanders and CNR develop charters for each of the Centers and the Corporate Laboratory for coordination by the RDT&E Facilities Consolidation Working Group and concurrence by ASN(RD&A).

- ASN(RD&A), working with the Chief of Naval Operations (CNO), will select, subject to my approval, qualified Flag Officers to command the four Centers prior to their establishment.

- ASN (RD&A), working with the Assistant Secretary of the Navy (Manpower and Reserve Affairs) (ASN(M&RA)) and the appropriate SYSCOM commander will approve Technical Directors for each of the Centers.

- SYSCOM Commanders jointly develop a plan to disestablish the existing affected activities and execute their orderly transfer to the newly formed Centers.

- ASN(M&RA), working with ASN(RD&A), the SYSCOM Commanders and CNR, develop a comprehensive plan for personnel transfers and downsizing.

- The Comptroller of the Navy, working with ASN(RD&A), the SYSCOM Commanders and CNR, establish a financial system for the Centers and Corporate Laboratory.

- The RDT&E Facilities Consolidation Working Group develop the charters for the Navy Laboratory/Center Commander's Group and the Navy Laboratory/ Center Oversight Council provide it to ASN(RD&A) for approval.

- The Office of the Chief of Naval Operations (OPNAV) and the Commander, Naval Air Systems Command coordinate with the U.S. Army and the Commander in Chief, Pacific Fleet regarding the potential transfer of flight operations at NAS Lakehurst and the transfer of custody of the Pacific Missile Range Facility, respectively.

The RDT&E, Engineering and Fleet Support Activities Consolidation Plan has far reaching, significant implications. The overriding concern in the development of this plan was to preserve the Department of the Navy's core mission capability to perform research, development, test and evaluation, as well as in-service engineering support for our operating forces. The magnitude of change represented in the plan was required in order to accommodate the mandated reductions within the Navy's budget and to the Acquisition Workforce. Implementing this plan is a challenge that we must meet together. I authorize and encourage you to share the consolidation plan with your personnel so that they may understand the full breadth of the effort.

Dan Howard for

H. Lawrence Garrett, III

RDT&E, ENGINEERING AND FLEET SUPPORT ACTIVITIES CONSOLIDATION PLAN

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I. INTRODUCTION

The consolidation of Research, Development, Test and Evaluation (RDT&E), Engineering and Fleet Support activities initiative began in October of 1989 as a result of the Defense Management Report (DMR). At that time, the draft version of DMR Decision (DMRD) 922, entitled "Consolidation of (R&D) Laboratories and T&E Facilities", was released. Throughout the following year, under the guidance of the Director, Defense Research and Engineering (DDR&E), the Services worked to develop a plan to achieve the required consolidation.

The Secretary of the Navy recognized the need to do preliminary planning for internal Navy consolidation regardless of the final form that DMRD 922 would take. As a result, in August of 1990, the Secretary formed the RDT&E Facilities Consolidation Working Group. He tasked the working group to develop the initial plans for internal Navy consolidation. In this tasking, the Secretary directed the group to include in its review all activities that executed RDT&E funds.

In October 1990, the Congress passed the Budget Enforcement Act of 1990. The effect of this Act was to decrease the Navy's Total Obligation Authority (TOA) by more than 21 percent from Fiscal Year 1990 to Fiscal Year 1995. The overall reduction in TOA was expected and was, to some degree, the driving force behind the consolidation of RDT&E, engineering and fleet support activities, as well as the consolidation of virtually all aspects of the Navy's infrastructure.

After consolidation planning was well underway the Defense Authorization Act of 1990 was signed into law in November 1990. This law mandates a twenty percent reduction in the Acquisition Workforce over a five year period beginning in Fiscal Year 1991. As defined, this provision of the law applies directly to the civilian personnel at the Navy's RDT&E, engineering and fleet support activities. The effect of this legislation is to drive the downsizing of the RDT&E, engineering and fleet support activities to a level significantly below that which was initially envisioned. The severity of the reduction made it imperative that the Navy find ways to make the most efficient use of its limited resources. As a consequence, the consolidation effort, which began as an effort to streamline and become more efficient, became an effort to preserve the Navy's core mission capability in spite of the mandated personnel and funding reductions.

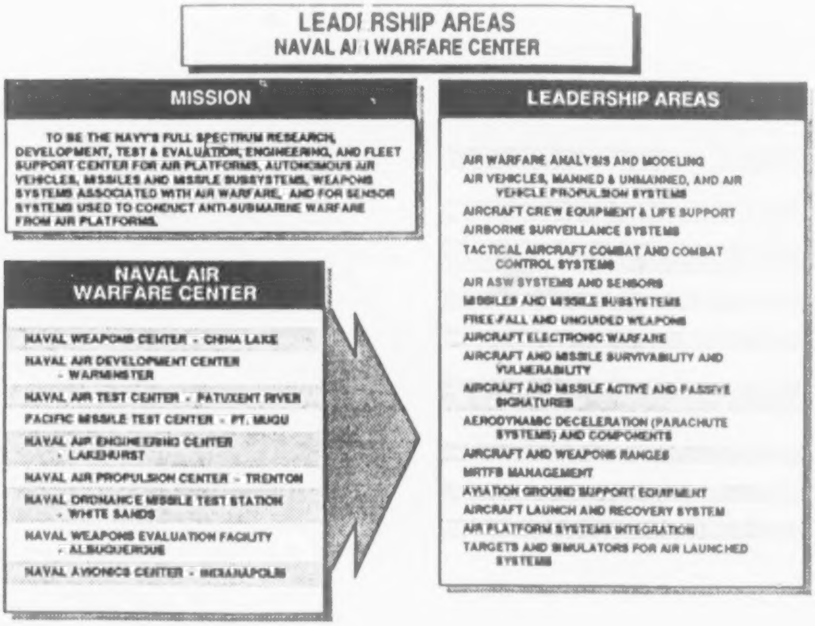
In November 1990, the Deputy Secretary of Defense signed DMRD 922. Under the decision each of the Services are directed to consolidate their RDT&E facilities internally while pursuing inter-service reliance in Science and Technology and Test and Evaluation.

In December of 1990, the working group presented a consolidation concept to the Secretary of the Navy which envisioned the formation of four Warfare Centers and a streamlined Department of the Navy (DON) Corporate Laboratory. Under the concept, the missions of each of the Centers and the Laboratory would be purified. Each center would be responsible for a unique set of functions or leadership areas. This purification of mission serves two purposes. The first is to eliminate unwarranted duplication of effort. The second purpose is to develop centers of technical excellence and a critical mass of capability by concentrating all of the work and talent associated with one technical area at one activity. The Secretary supported the concept and directed that the Systems Command (SYSCOM) Commanders and the Chief of Naval Research (CNR) develop detailed plans for implementing the concept. This plan, which the Secretary has approved, is the result of that effort. This plan is a phased plan which is to be completed by the end of Fiscal Year 1995 governed by the availability of resources to execute the plan.

II. CONSOLIDATED STRUCTURE

The resulting structure of the RDT&E, engineering and fleet support activities consists of four full spectrum warfare centers, consciously aligned by mission, and a single DON corporate laboratory assigned broad responsibility for scientific research and advanced technological development including Space and Space Systems technology. Each of the Warfare Centers are uniquely assigned functional leadership areas. Through this assignment process, unwarranted duplication of effort will be reduced and a critical mass of capability will be created at each of the centers.

A. NAVAL AIR WARFARE CENTER (NAWC). The Naval Air Warfare Center is the full spectrum center for air platforms and air warfare combat and weapons systems. The NAWC reports directly to the Commander, Naval Air Systems Command. The mission, unique leadership areas and a list of those activities which were, either in total or in part, consolidated into the Center are shown in Figure 1. The Naval Air Warfare Center is organized into two major divisions; the Aircraft Division on the East Coast and the Weapons Division on the West Coast.



TO BE THE NAVY'S FULL SPECTRUM RESEARCH, DEVELOPMENT, TEST & EVALUATION, ENGINEERING, AND FLEET SUPPORT CENTER FOR AIR PLATFORMS, AUTONOMOUS AIR VEHICLES, MISSILES AND MISSILE SUBSYSTEMS, WEAPONS SYSTEMS ASSOCIATED WITH AIR WARFARE, AND FOR SENSOR SYSTEMS USED TO CONDUCT ANTI-SUBMARINE WARFARE FROM AIR PLATFORMS.

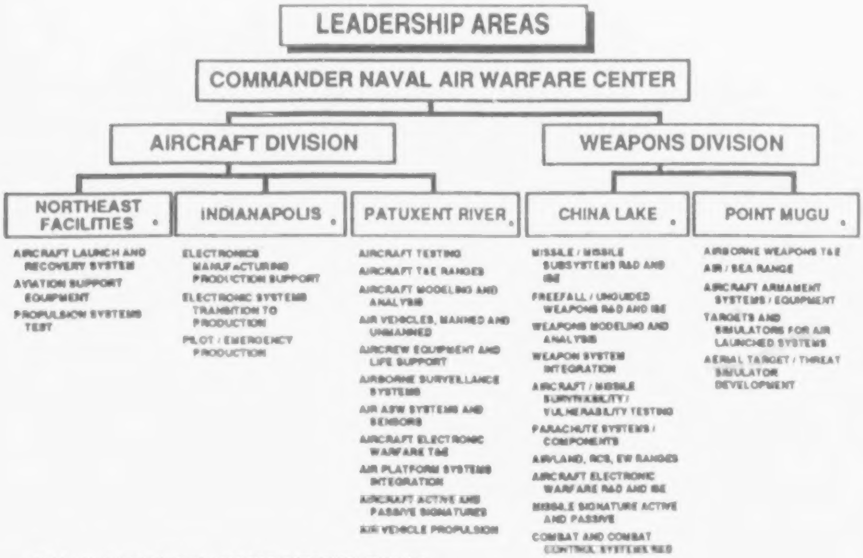
NAVAL WEAPONS CENTER - CHINA LAKE
NAVAL AIR DEVELOPMENT CENTER - WARMINSTER
NAVAL AIR TEST CENTER - PATUXENT RIVER
PACIFIC MISSILE TEST CENTER - PT. MUGU
NAVAL AIR ENGINEERING CENTER - LAKEHURST
NAVAL AIR PROPULSION CENTER - TRENTON
NAVAL ORDNANCE MISSILE TEST STATION - WHITE SANDS
NAVAL WEAPONS EVALUATION FACILITY - ALBUQUERQUE
NAVAL AVIONICS CENTER - INDIANAPOLIS

AIR WARFARE ANALYSIS AND MODELING
AIR VEHICLES, MANNED & UNMANNED, AND AIR VEHICLE PROPULSION SYSTEMS
AIRCRAFT CREW EQUIPMENT & LIFE SUPPORT
AIRBORNE SURVEILLANCE SYSTEMS
TACTICAL AIRCRAFT COMBAT AND COMBAT CONTROL SYSTEMS
AIR ASW SYSTEMS AND SENSORS
MISSILES AND MISSILE SUBSYSTEMS
FREE-FALL AND UNGUIDED WEAPONS
AIRCRAFT ELECTRONIC WARFARE
AIRCRAFT AND MISSILE SURVIVABILITY AND VULNERABILITY
AIRCRAFT AND MISSILE ACTIVE AND PASSIVE SIGNATURES
AERODYNAMIC DECELERATION (PARACHUTE SYSTEMS) AND COMPONENTS
AIRCRAFT AND WEAPONS RANGES
MRTFB MANAGEMENT
AVIATION GROUND SUPPORT EQUIPMENT
AIRCRAFT LAUNCH AND RECOVERY SYSTEM
AIR PLATFORM SYSTEMS INTEGRATION
TARGETS AND SIMULATORS FOR AIR LAUNCHED SYSTEMS

FIGURE 1

1. Aircraft Division. The Aircraft Division, centered at Patuxent River, MD, is primarily responsible for aircraft, engines, avionics and aircraft support. Specific leadership areas are delineated by location in Figure 2. The division will also have activities located at Indianapolis, IN and Lakehurst, NJ, and facilities at Trenton, NJ.

2. Weapons Division. The Weapons Division, centered at Point Mugu, CA and China Lake, CA, is primarily responsible for the development of aircraft weapons and weapons systems, simulators and targets. Specific leadership areas are delineated by location in Figure 2. The division will also have a facility at White Sands, NM.


LEADERSHIP AREAS
COMMANDER NAVAL AIR WARFARE CENTER
AIRCRAFT DIVISION
WEAPONS DIVISION
NORTHEAST FACILITIES *
INDIANAPOLIS *
PATUXENT RIVER *
CHINA LAKE *
POINT MUGU *
AIRCRAFT LAUNCH AND RECOVERY SYSTEM
AVIATION SUPPORT EQUIPMENT
PROPULSION SYSTEMS TEST
ELECTRONICS MANUFACTURING PRODUCTION SUPPORT
ELECTRONIC SYSTEMS TRANSITION TO PRODUCTION
PILOT / EMERGENCY PRODUCTION
AIRCRAFT TESTING
AIRCRAFT T&E RANGES
AIRCRAFT MODELING AND ANALYSIS
AIR VEHICLES, MANNED AND UNMANNED
AIRCREW EQUIPMENT AND LIFE SUPPORT
AIRBORNE SURVEILLANCE SYSTEMS
AIR ASW SYSTEMS AND SENSORS
AIRCRAFT ELECTRONIC WARFARE T&E
AIR PLATFORM SYSTEMS INTEGRATION
AIRCRAFT ACTIVE AND PASSIVE SIGNATURES
AIR VEHICLE PROPULSION
MISSILE / MISSILE SUBSYSTEMS R&D AND ISE
FREEFALL / UNGUIDED WEAPONS R&D AND ISE
WEAPONS MODELING AND ANALYSIS
WEAPON SYSTEM INTEGRATION
AIRCRAFT / MISSILE SURVIVABILITY / VULNERABILITY TESTING
PARACHUTE SYSTEMS / COMPONENTS
AIR/LAND, RCS, EW RANGES
AIRCRAFT ELECTRONIC WARFARE R&D AND ISE
MISSILE SIGNATURE ACTIVE AND PASSIVE
COMBAT AND COMBAT CONTROL SYSTEMS R&D
AIRBORNE WEAPONS T&E
AIR / SEA RANGE
AIRCRAFT ARMAMENT SYSTEMS / EQUIPMENT
TARGETS AND SIMULATORS FOR AIR LAUNCHED SYSTEMS
AERIAL TARGET / THREAT SIMULATOR DEVELOPMENT

*BASE COMMANDER SUBORDINATE TO THE TECHNICAL DIVISIONS
NOTE: MRTFB MANAGEMENT AT HEADQUARTERS

FIGURE 2

B. NAVAL SURFACE WARFARE CENTER (NSWC). The Naval Surface Warfare Center is the full spectrum center for surface platforms and surface warfare combat and weapons systems. It is also the focal point for all ship and submarine hull, mechanical and electrical programs. The NSWC reports directly to the Commander, Naval Sea Systems Command. The mission; unique leadership areas, and a list of those activities which were, either in total or in part, consolidated into the Center are shown in Figure 3. The NSWC is organized into four functional divisions: the Combat and Weapon Systems Research and Development (R&D) Division, the Combat and Weapon Systems In-Service Engineering (ISE) Division, the Combat and Weapon System Engineering and Industrial Base Division, and the Hull, Mechanical and Electrical (HM&E) R&D and ISE Division.

LEADERSHIP AREAS NAVAL SURFACE WARFARE CENTER

MISSION

TO BE THE NAVY'S FULL SPECTRUM RESEARCH, DEVELOPMENT, TEST AND EVALUATION, ENGINEERING, AND FLEET SUPPORT CENTER FOR SHIP HULL, MECHANICAL AND ELECTRICAL SYSTEMS, SURFACE SHIP COMBAT SYSTEMS, COASTAL WARFARE SYSTEMS, AND OTHER OFFENSIVE AND DEFENSIVE SYSTEMS ASSOCIATED WITH SURFACE WARFARE.

ACTIVITIES

NAVAL SURFACE WARFARE CENTER
    - DAHLGREN, WHITE OAK
DAVID TAYLOR RESEARCH CENTER
    - CARDEROCK, ANNAPOLIS
FLEET COMBAT DIRECTION SYSTEMS SUPPORT ACTIVITY
    - DAM NECK
NAVAL SHIP WEAPONS SYSTEMS ENGINEERING STATION
    - PT. HUENEME
NAVAL SHIP SYSTEMS ENGINEERING STATION
    - PHILADELPHIA
NAVAL WEAPONS SUPPORT CENTER - CRANE
NAVAL ORDNANCE STATION - INDIAN HEAD
INTEGRATED COMBAT SYSTEMS TEST FACILITY
    - SAN DIEGO
NAVAL COASTAL SYSTEMS CENTER
    - PANAMA CITY
NAVAL MINE WARFARE ENGINEERING ACTIVITY
    - YORKTOWN
NAVAL ORDNANCE STATION - LOUISVILLE

LEADERSHIP AREAS

SURFACE WARFARE ANALYSIS AND MODELING

SURFACE SHIP COMBAT AND COMBAT CONTROL SYSTEMS

SURFACE SHIP ELECTRONIC WARFARE

SURFACE SHIP ELECTROMAGNETIC AND ELECTRO-OPTIC RECONNAISSANCE, SEARCH & TRACK SYSTEMS

SURFACE SHIP WEAPON SYSTEMS

SURFACE SHIP VULNERABILITY AND SURVIVABILITY

SHIP ACTIVE & PASSIVE SIGNATURES

SURFACE AND UNDERSEA VEHICLE HULL, MACHINERY, PROPULSORS AND EQUIPMENT

PLATFORM SYSTEMS INTEGRATION

STRATEGIC TARGETING SUPPORT

AMPHIBIOUS WARFARE SYSTEMS

SPECIAL WARFARE SYSTEMS

WARHEADS

MINES, MINE COUNTERMEASURES, MINE CLEARANCE SYSTEMS

FIGURE 3

1. **Combat and Weapons Systems R&D Division.** The Combat and Weapons System R&D Division is primarily responsible for Surface Combat and Weapons Systems, Mine and Amphibious Warfare and Mine Countermeasures. Specific leadership areas are delineated by location in Figure 4. The Division is centered at Dahlgren, VA with an operating site at Panama City, FL and facilities at White Oak, MD.

2. **Combat and Weapon System In-Service Engineering Division.** The Combat and Weapon System In-Service Engineering (ISE) Division is primarily responsible for in-service engineering to surface ships and mines, underway replenishment and combat systems software. Specific leadership areas are delineated by location in Figure 4. The Division is centered at Port Hueneme, CA with an operating site at Dam Neck, VA.

3. **Combat and Weapon System Engineering and Industrial Base Division.** The Combat and Weapon System Engineering and Industrial Base Division is primarily responsible for gun systems, ordnance and explosives. Specific leadership areas are delineated by location in Figure 4. The Division is centered at Crane, IN with operating sites at Louisville, KY and Indian Head, MD.

4. **HM&E R&D and ISE Division.** The HM&E R&D and ISE Division is primarily responsible for ship and submarine HM&E and propulsion. Specific leadership areas are delineated by location in Figure 4. The Division is centered at Carderock, MD with an operating site at Philadelphia and facilities at Annapolis, MD.

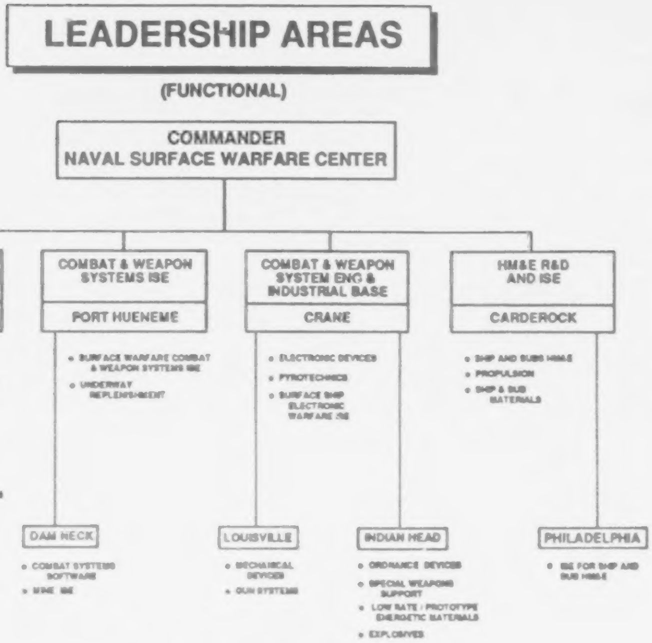
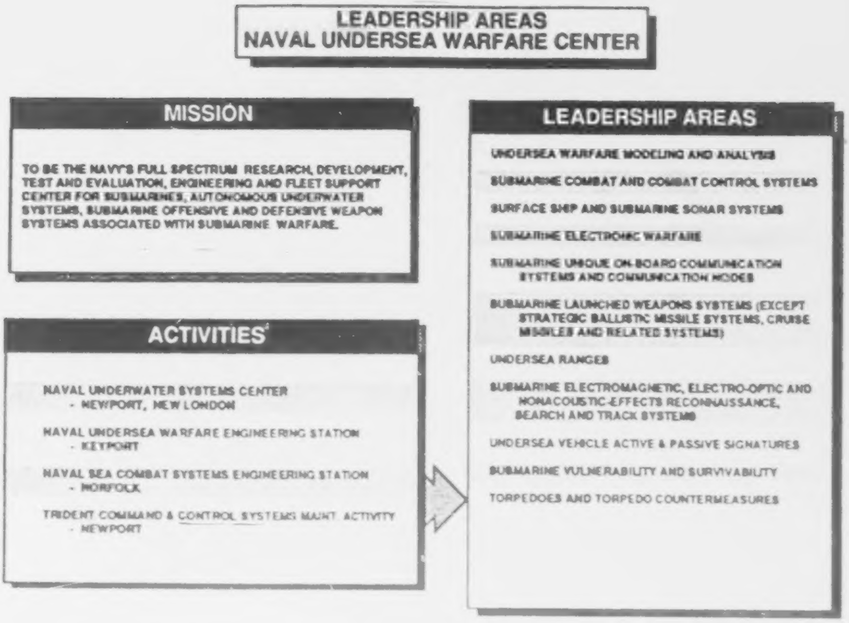

LEADERSHIP AREAS
(FUNCTIONAL)
COMMANDER NAVAL SURFACE WARFARE CENTER
COMBAT & WEAPON SYSTEMS R&D
DAHLGREN
• SURFACE SHIP ELECTRONIC WARFARE
• SURFACE WARFARE COMBAT AND WEAPONS SYSTEMS
• U/W MINES
• DIRECTED ENERGY
• NUCLEAR WEAPONS EFFECTS
• SURFACE SHIP MISSILE INTEGRATION
• SURFACE WARFARE ANALYSIS MODELING
COMBAT & WEAPON SYSTEMS ISE
PORT HUENEME
• SURFACE WARFARE COMBAT & WEAPON SYSTEMS ISE
• UNDERWAY REPLENISHMENT
COMBAT & WEAPON SYSTEM ENG & INDUSTRIAL BASE
CRANE
• ELECTRONIC DEVICES
• PYROTECHNICS
• SURFACE SHIP ELECTRONIC WARFARE ISE
HM&E R&D AND ISE
CARDEROCK
• SHIP AND SUBS HM&E
• PROPULSION
• SHIP & SUB MATERIALS
PANAMA CITY
• AMPHIBIOUS WARFARE
• DIVING AND SALVAGE
• MINE COUNTERMEASURES
• SPECIAL WARFARE
DAM NECK
• COMBAT SYSTEMS SOFTWARE
• MINE ISE
LOUISVILLE
• MECHANICAL DEVICES
• GUN SYSTEMS
INDIAN HEAD
• ORDNANCE DEVICES
• SPECIAL WEAPONS SUPPORT
• LOW RATE / PROTOTYPE ENERGETIC MATERIALS
• EXPLOSIVES
PHILADELPHIA
• ISE FOR SHIP AND SUB HM&E

FIGURE 4

C. NAVAL UNDERSEA WARFARE CENTER (NUWC). The Naval Undersea Warfare Center is the full spectrum center for submarine sensors and submarine combat and weapon systems. The NUWC reports directly to the Commander, Naval Sea Systems Command. The mission, unique leadership areas, and a list of those activities which were, either in total or in part, consolidated into the Center are shown in Figure 5. The NUWC is organized into two divisions, the Weapons and Combat Systems Division and the Weapons System ISE Division.



LEADERSHIP AREAS
NAVAL UNDERSEA WARFARE CENTER

MISSION

TO BE THE NAVY'S FULL SPECTRUM RESEARCH, DEVELOPMENT, TEST AND EVALUATION, ENGINEERING AND FLEET SUPPORT CENTER FOR SUBMARINES, AUTONOMOUS UNDERWATER SYSTEMS, SUBMARINE OFFENSIVE AND DEFENSIVE WEAPON SYSTEMS ASSOCIATED WITH SUBMARINE WARFARE.

ACTIVITIES

NAVAL UNDERWATER SYSTEMS CENTER
- NEWPORT, NEW LONDON

NAVAL UNDERSEA WARFARE ENGINEERING STATION
- KEYPORT

NAVAL SEA COMBAT SYSTEMS ENGINEERING STATION
- NORFOLK

TRIDENT COMMAND & CONTROL SYSTEMS MAINT. ACTIVITY
- NEWPORT

LEADERSHIP AREAS

UNDERSEA WARFARE MODELING AND ANALYSIS

SUBMARINE COMBAT AND COMBAT CONTROL SYSTEMS

SURFACE SHIP AND SUBMARINE SONAR SYSTEMS

SUBMARINE ELECTRONIC WARFARE

SUBMARINE UNIQUE ON-BOARD COMMUNICATION SYSTEMS AND COMMUNICATION NODES

SUBMARINE LAUNCHED WEAPONS SYSTEMS (EXCEPT STRATEGIC BALLISTIC MISSILE SYSTEMS, CRUISE MISSILES AND RELATED SYSTEMS)

UNDERSEA RANGES

SUBMARINE ELECTROMAGNETIC, ELECTRO-OPTIC AND NONACOUSTIC-EFFECTS RECONNAISSANCE, SEARCH AND TRACK SYSTEMS

UNDERSEA VEHICLE ACTIVE & PASSIVE SIGNATURES

SUBMARINE VULNERABILITY AND SURVIVABILITY

TORPEDOES AND TORPEDO COUNTERMEASURES

FIGURE 5

1. **Combat and Weapon Systems Division.** The Combat and Weapon Systems Division, centered at Newport, RI, is primarily responsible for submarine combat and weapon systems and combat systems ISE. Specific leadership areas are delineated by location in Figure 6. The Division will have an operating site at Norfolk,VA and facilities at New London, CT.

2. **Weapons Systems ISE Division.** The Weapons Systems ISE Division is comprised solely of the operating site at Keyport, WA. Specific leadership areas are delineated by location in Figure 6.

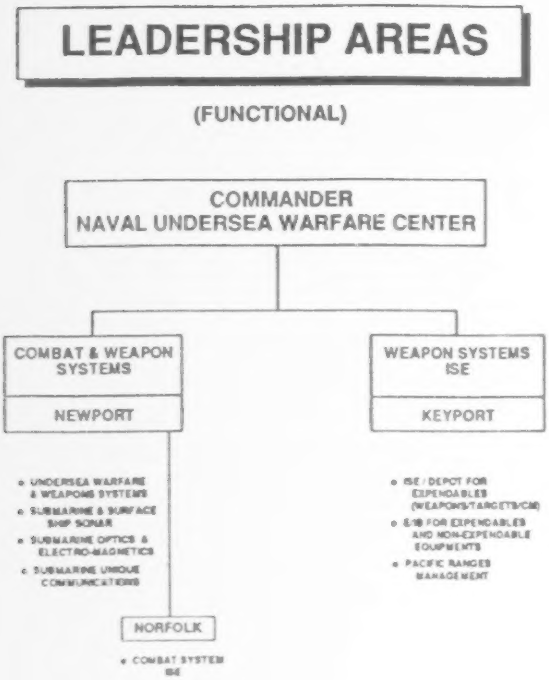
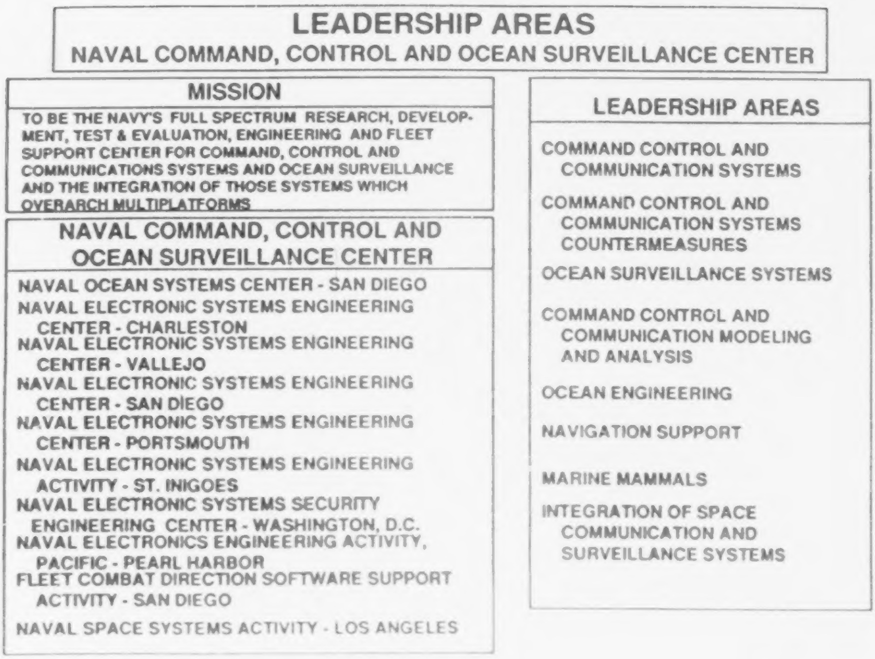

LEADERSHIP AREAS
(FUNCTIONAL)
COMMANDER NAVAL UNDERSEA WARFARE CENTER
COMBAT & WEAPON SYSTEMS
NEWPORT
• UNDERSEA WARFARE & WEAPONS SYSTEMS
• SUBMARINE & SURFACE SHIP SONAR
• SUBMARINE OPTICS & ELECTRO-MAGNETICS
• SUBMARINE UNIQUE COMMUNICATIONS
NORFOLK
• COMBAT SYSTEM ISE
WEAPON SYSTEMS ISE
KEYPORT
• ISE / DEPOT FOR EXPENDABLES (WEAPONS/TARGETS/CM)
• I/M FOR EXPENDABLES AND NON-EXPENDABLE EQUIPMENTS
• PACIFIC RANGES MANAGEMENT

FIGURE 6

D. NAVAL COMMAND, CONTROL AND OCEAN SURVEILLANCE CENTER (NCCOSC). The Naval Command, Control and Ocean Surveillance Center is the full spectrum center for maritime Command, Control and Communications and Intelligence (C3I), ocean surveillance technology and fleet and shore support. The NCCOSC reports directly to the Commander, Space and Naval Warfare Command. The mission, unique leadership areas, and a list of those activities which were, either in total or in part, consolidated into the center are shown in Figure 7. The NCCOSC is organized into three major directorates, the RDT&E Directorate, the West Coast ISE Directorate and the East Coast ISE Directorate. The West Coast ISE Directorate is collocated with the RDT&E Directorate.



LEADERSHIP AREAS
NAVAL COMMAND, CONTROL AND OCEAN SURVEILLANCE CENTER

MISSION

TO BE THE NAVY'S FULL SPECTRUM RESEARCH, DEVELOPMENT, TEST & EVALUATION, ENGINEERING AND FLEET SUPPORT CENTER FOR COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS AND OCEAN SURVEILLANCE AND THE INTEGRATION OF THOSE SYSTEMS WHICH OVERARCH MULTIPLATFORMS

NAVAL COMMAND, CONTROL AND OCEAN SURVEILLANCE CENTER

NAVAL OCEAN SYSTEMS CENTER - SAN DIEGO
NAVAL ELECTRONIC SYSTEMS ENGINEERING CENTER - CHARLESTON
NAVAL ELECTRONIC SYSTEMS ENGINEERING CENTER - VALLEJO
NAVAL ELECTRONIC SYSTEMS ENGINEERING CENTER - SAN DIEGO
NAVAL ELECTRONIC SYSTEMS ENGINEERING CENTER - PORTSMOUTH
NAVAL ELECTRONIC SYSTEMS ENGINEERING ACTIVITY - ST. INIGOES
NAVAL ELECTRONIC SYSTEMS SECURITY ENGINEERING CENTER - WASHINGTON, D.C.
NAVAL ELECTRONICS ENGINEERING ACTIVITY, PACIFIC - PEARL HARBOR
FLEET COMBAT DIRECTION SOFTWARE SUPPORT ACTIVITY - SAN DIEGO
NAVAL SPACE SYSTEMS ACTIVITY - LOS ANGELES

LEADERSHIP AREAS

COMMAND CONTROL AND COMMUNICATION SYSTEMS
COMMAND CONTROL AND COMMUNICATION SYSTEMS COUNTERMEASURES
OCEAN SURVEILLANCE SYSTEMS
COMMAND CONTROL AND COMMUNICATION MODELING AND ANALYSIS
OCEAN ENGINEERING
NAVIGATION SUPPORT
MARINE MAMMALS
INTEGRATION OF SPACE COMMUNICATION AND SURVEILLANCE SYSTEMS

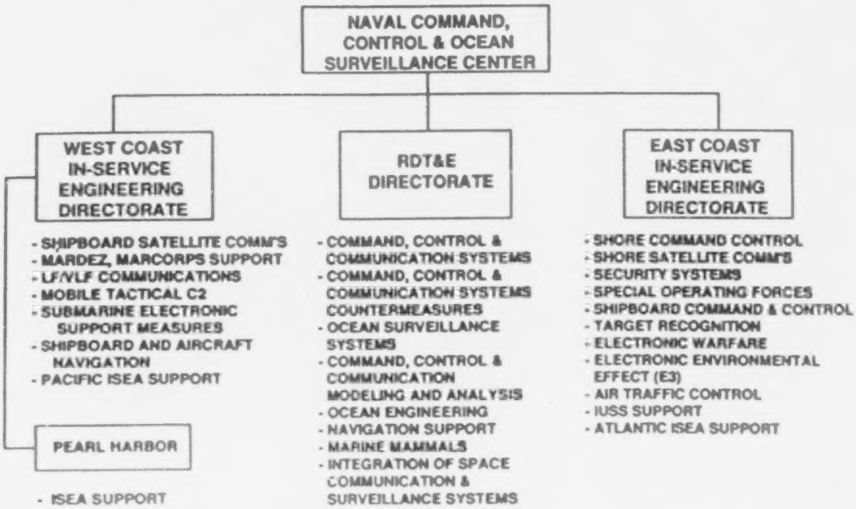
FIGURE 7

1. **RDT&E Directorate**. The RDT&E Directorate is primarily responsible for the development of C3I systems, ocean surveillance systems and navigation support. Specific leadership areas are delineated by location in Figure 8. The Directorate will be located at San Diego, CA and will have facilities at Warminster, PA.

2. **West Coast ISE Directorate**. The West Coast ISE Directorate is primarily responsible for shipboard satellite communications, navigation and Pacific ISE support. Specific leadership areas are delineated by location in Figure 8. The Directorate will be collocated with the RDT&E Directorate at San Diego and have an operating site at Pearl Harbor, HI.

3. **East Coast ISE Directorate**. The East Coast ISE Directorate is primarily responsible for shore communications, air traffic control and Atlantic ISE support. Specific leadership areas are delineated by location in Figure 8. The Directorate is solely located at Portsmouth, VA.

LEADERSHIP AREAS



NAVAL COMMAND, CONTROL & OCEAN SURVEILLANCE CENTER

WEST COAST IN-SERVICE ENGINEERING DIRECTORATE

- SHIPBOARD SATELLITE COMM'S
- MARDEZ, MARCORPS SUPPORT
- LF/VLF COMMUNICATIONS
- MOBILE TACTICAL C2
- SUBMARINE ELECTRONIC SUPPORT MEASURES
- SHIPBOARD AND AIRCRAFT NAVIGATION
- PACIFIC ISEA SUPPORT

PEARL HARBOR

- ISEA SUPPORT

RDT&E DIRECTORATE

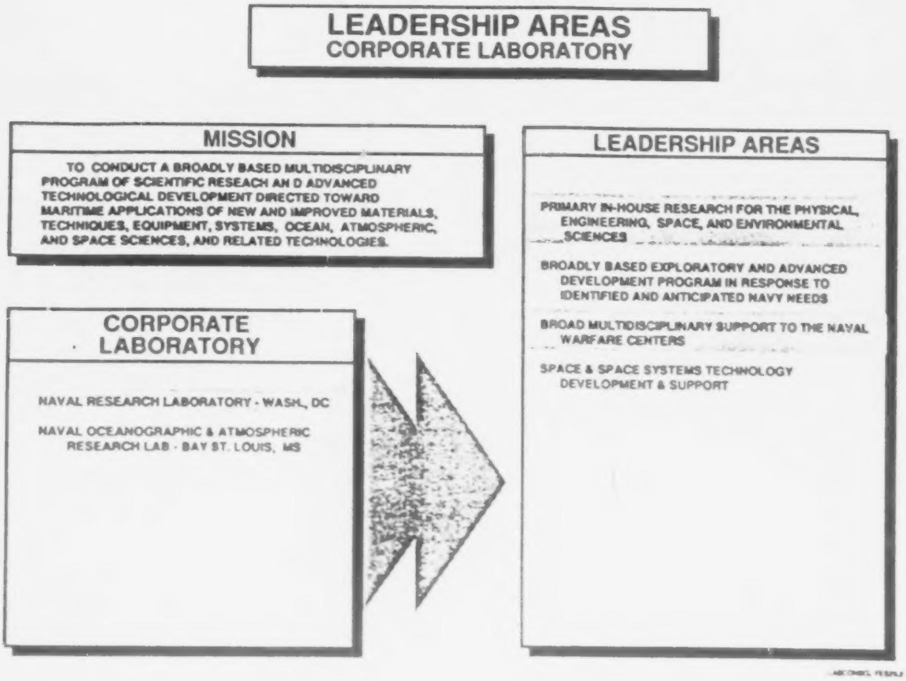
- COMMAND, CONTROL & COMMUNICATION SYSTEMS
- COMMAND, CONTROL & COMMUNICATION SYSTEMS COUNTERMEASURES
- OCEAN SURVEILLANCE SYSTEMS
- COMMAND, CONTROL & COMMUNICATION MODELING AND ANALYSIS
- OCEAN ENGINEERING
- NAVIGATION SUPPORT
- MARINE MAMMALS
- INTEGRATION OF SPACE COMMUNICATION & SURVEILLANCE SYSTEMS

EAST COAST IN-SERVICE ENGINEERING DIRECTORATE

- SHORE COMMAND CONTROL
- SHORE SATELLITE COMM'S
- SECURITY SYSTEMS
- SPECIAL OPERATING FORCES
- SHIPBOARD COMMAND & CONTROL
- TARGET RECOGNITION
- ELECTRONIC WARFARE
- ELECTRONIC ENVIRONMENTAL EFFECT (E3)
- AIR TRAFFIC CONTROL
- IUSS SUPPORT
- ATLANTIC ISEA SUPPORT

FIGURE 8

E. NAVAL RESEARCH LABORATORY. The Naval Research Laboratory (NRL) is the Navy's single, integrated corporate laboratory and is assigned broad responsibility for scientific research and advanced technology development. The NRL reports directly to the Chief of Naval Research. The mission, unique leadership areas, and a list of those activities which were, either in total or in part, consolidated into the Laboratory are shown in Figure 9. NRL is centered in Washington, D.C. with major operating sites at Stennis Space Center, MS; Monterey, CA; and Orlando, FL.



LEADERSHIP AREAS
CORPORATE LABORATORY

MISSION

TO CONDUCT A BROADLY BASED MULTIDISCIPLINARY PROGRAM OF SCIENTIFIC RESEACH AN D ADVANCED TECHNOLOGICAL DEVELOPMENT DIRECTED TOWARD MARITIME APPLICATIONS OF NEW AND IMPROVED MATERIALS, TECHNIQUES, EQUIPMENT, SYSTEMS, OCEAN, ATMOSPHERIC, AND SPACE SCIENCES, AND RELATED TECHNOLOGIES.

CORPORATE LABORATORY

NAVAL RESEARCH LABORATORY - WASH., DC

NAVAL OCEANOGRAPHIC & ATMOSPHERIC RESEARCH LAB - BAY ST. LOUIS, MS

LEADERSHIP AREAS

PRIMARY IN-HOUSE RESEARCH FOR THE PHYSICAL, ENGINEERING, SPACE, AND ENVIRONMENTAL SCIENCES

BROADLY BASED EXPLORATORY AND ADVANCED DEVELOPMENT PROGRAM IN RESPONSE TO IDENTIFIED AND ANTICIPATED NAVY NEEDS

BROAD MULTIDISCIPLINARY SUPPORT TO THE NAVAL WARFARE CENTERS

SPACE & SPACE SYSTEMS TECHNOLOGY DEVELOPMENT & SUPPORT

FIGURE 9

1. **Naval Research Laboratory (NRL), Washington.** NRL Washington conducts a broad program of research and advanced technology development with specific leadership areas as delineated in Figure 10.

2. **NRL, Stennis Space Center, MS.** NRL, Stennis Space Center is responsible for Navy research in Oceanography and Mapping, Charting and Geodesy (MC&G). It is collocated with its major customer, the Naval Oceanographic Office.

3. **NRL, Monterey, CA.** NRL, Monterey is responsible for Navy research in Meteorology. It is collocated with its major customer, the Fleet Numerical Oceanography Center.

4. **NRL, Orlando, FL.** NRL, Orlando is the Navy center of expertise for acoustic transducer resarch, calibration, test, measurement and standards.

LEADERSHIP AREAS

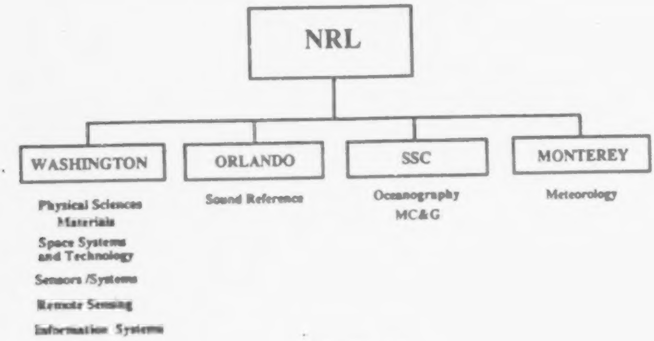


FIGURE 10

III. IMPLEMENTATION ACTIONS

Implementation of this consolidation plan requires a wide variety of actions to occur, ranging from the disestablishment and establishment of commands to the development of appropriate financial systems. A number of these actions have been outlined in detail while others are still being defined.

A. MISSION PURIFICATION. One of the primary purposes of the consolidation effort is to prevent unwarranted duplication of effort. This is achieved through purifying the missions of the Centers and the Corporate Laboratory. Through this process, technical expertise and associated work will be centered at one location. In addition to reducing unwarranted duplication, this action, over time, will create centers of excellence in specific technical areas. A representative set of the major functional transfers that will take place between the Centers to purify their missions is shown in Figure 11.

FUNCTION	FROM	TO
Missiles & Missile Subsystems	SURFACE	AIR
Navigation & Navigation Support	AIR	NCCOSC
Communications	AIR	NCCOSC
C3 Software	SURFACE	NCCOSC
Warheads	AIR	SURFACE
Surface ASW	UNDERSEA	SURFACE
SURFACE ASW Control	NCCOSC	SURFACE
VLA/ASROC Integration	NCCOSC	SURFACE
Surface Radar	UNDERSEA	SURFACE
Small Boat/Combat Craft Design	UNDERSEA	SURFACE
Torpedo & SONAR CM	SURFACE	UNDERSEA
Submarine ASW CM	SURFACE	UNDERSEA
Miscellaneous Submarine Systems	SURFACE	UNDERSEA
Lightweight Torpedoes	NCCOSC	UNDERSEA
Torpedo Simulation	NCCOSC	UNDERSEA
Mobile Sonar Simulators	NCCOSC	UNDERSEA
Autonomous Underwater Systems	NCCOSC	UNDERSEA
Arctic Warfare	NCCOSC	UNDERSEA

FIGURE 11

Beginning on 1 October 1991, a Center or one of its components may accept customer work only in a leadership area assigned to them. Program managers will still have the authority to work directly with the activities performing their work, but they will no longer have the freedom to direct their work to any Navy RDT&E activity willing to perform that work. The Corporate Laboratory will continue to maintain and execute a broad multi-disciplinary technical program for the Navy working directly with program managers and Centers as appropriate.

B. PERSONNEL TRANSFERS

The purification of the missions of the Centers and the Corporate Laboratory will result in the transfer of some functions from one location to another. These functional transfers will, in turn, result in personnel relocations. The detailed plans to effect these relocations will part of the overall plan being developed to address personnel issues as identified later.

C. MANDATED PERSONNEL REDUCTIONS

The consolidation of functions and overhead described in this plan, as well as the streamlining of operations, will create significant billet reductions. However, the Congressionally mandated Acquisition Workforce billet reductions exceed those expected to be gained through consolidation. The starting point for determining the level of legislated personnel reduction for a particular Center is the actual on-board manning level as of 30 September 1990 assuming the inter-Center functional transfers had taken place. From that figure, the 20 percent reduction is calculated. In developing the billet reductions, reductions in overhead should be the first priority and should be a large as possible in order to protect the Navy's technical capability. Nevertheless, Congress has mandated a reduction of approximately 13,000 personnel from the activities involved in this consolidation, and some reduction in direct labor beyond that saved through the consolidation process will be required. All reductions must be taken across the entire grade structure. The remaining reductions should be tied to programmatic decreases to the extent feasible.

D. SPECIFIC ACTIONS

1. NAVAL AIR WARFARE CENTER

The Naval Air Warfare Center will be formed in four stages. On or before 1 October 1991, NAWC will be established under the command of a Flag Officer assisted by a Senior Executive Technical Director who are collocated with the Naval Air Systems Command in Washington, D.C. This action will result in no increase in the overall size of the Washington, D.C. staff. At the same time, the Aircraft Division and Weapons Division will be established and the nine technical activities that are consolidated into the NAWC will be disestablished as separate reporting activities and restructured as integral components of the Aircraft and Weapons Divisions of the NAWC with the goal of minimizing overhead and infrastructure.

a. Aircraft Division. Establish the Aircraft Division under the command of a Flag Officer headquartered at Patuxent River, MD. The Aircraft Division will utilize the facilities at St. Inigoes, MD received from NCCOSC. The components formed from the activities listed below are subordinate to the Commander, Aircraft Division until their mergers with the division. In addition the following actions are required to complete the consolidation.

Naval Air Development Center (NADC)	
- Commence inter-center functional transfers	OCT 91
- Commence transfer of technical functions	OCT 91
- Functional realignment complete	OCT 93
- Complete transfer of NAWC functions / NCCOSC maintains and operates facilities at Warminster	OCT 95

Naval Air Propulsion Center (NAPC)	
- Commence transfer of large, high altitude engine testing to Air Force	OCT 91
- Functional realignment complete	OCT 93
- Commence transfer of Engineering personnel to Aircraft Division, Pax River	OCT 94
- Maintain and operate unique engine test cells	JAN 94

Naval Air Engineering Center (NAEC)	
- Functional realignment complete	OCT 93
- Establish Naval Air Engineering Station which reports to Commander, Aircraft Division	OCT 93
- Maintain as an operating site	

Naval Avionics Center (NAC)	
- Commence inter-center functional transfers	OCT 91
- Functional realignment complete	OCT 94
- Establish Naval Avionics Facility, Indianapolis reporting to Commander, Aircraft Division	OCT 94
- Maintain as an operating site	

Naval Air Test Center (NATC)	
- Disestablish as a separate technical command merge with Aircraft Division	OCT 91
- Become central site of Aircraft Division	OCT 91
- NAS Pax River reports to Commander, Aircraft Division	OCT 91
- Maintain as an operating site	

b. Weapons Division. Establish the Weapons Division under the command of a Flag Officer. In addition the following actions are required to complete the consolidation.

Naval Weapons Center (NWC)	
- Disestablish as a separate technical command merge with Weapons Division, retain base support functions	OCT 91
- Commence inter-center functional transfers	OCT 91
- Functional realignment complete	OCT 92
- Establish Naval Air Weapons Station, China Lake reporting to Commander, Weapons Division	OCT 92
- Retain as an operating site	

Pacific Missile Test Center (PMTC)	
- Disestablish as a separate technical command merge with Weapons Division	OCT 91
- C.O. NAS Pt. Mugu reports to Commander, Weapons Division	OCT 91
- C.O. Pacific Missile Range Facility reports to Commander, Weapons Division	OCT 91
- Retain as an operating site	

Naval Ordnance Missile Test Station (NOMTS)

- Commence downsizing and operate as a facility reporting to Commander, Weapons Division	OCT 91

Naval Weapons Evaluation Facility (NWEF)

- Commence transfer functions Weapons Division	OCT 91
- Close NWEF	OCT 93

2. NAVAL SURFACE WARFARE CENTER

The Naval Surface Warfare Center will be established on or before 1 October 1991 under the command of a Flag Officer assisted by a Senior Executive Technical Director who are collocated with the Naval Sea Systems Command in Washington, D.C. This action will result in no increase to the overall size of the Washington, D.C. staff. At the same time, the thirteen technical activities that are consolidated into NSWC will be disestablished as separate reporting activities and restructured as integral components of NSWC with the goal of minimizing overhead and infrastructure. The components of NSWC will be organized into divisions of like functions (RDT&E, ISE and production engineering/industrial base).

a. Combat and Weapon System R&D Division. The Combat and Weapon System R&D Division is centered at Dahlgren, VA. The following actions are required to complete the consolidation.

Naval Coastal Systems Center (NCSC)

- Organizationally align with Dahlgren	OCT 91
- Commence transfer of functions	OCT 91
- Maintain as an operating site	

Naval Surface Warfare Center Detachment White Oak (NSWC)

- Initiate downsizing	OCT 91
- Commence transfer of functions	OCT 91
- Operate as a facility	OCT 95
- Continue to downsize as feasible	ONGOING

Naval Surface Warfare Center (NSWC)

- Become center for Combat & Weapon System RDT&E Division	OCT 91

b. Combat and Weapon Systems ISE Division. The Combat and Weapon System ISE Division is centered at Port Hueneme, CA. The following actions are required to complete the consolidation.

Integrated Combat Systems Test Facility (ICSTF)

- Organizationally align with Port Hueneme	OCT 91
- Commence transfer of functions	OCT 91
- Close ICSTF	OCT 95

Naval Mine Warfare Engineering Activity (NMWEA)

- Commence transfer of functions	OCT 91
- Transfer remaining functions to Dam Neck	MAR 93
- Close NMWEA	MAR 94

Fleet Combat Direction Systems Support Activity (FCDSSA)

- Organizationally align with Port Hueneme	OCT 91
- Become East Coast ISE site	OCT 91

Naval Ship Weapon Systems Engineering Station (NSWSES)

- Become center for Combat & Weapons Systems ISE Division	OCT 91

c. Combat and Weapon System Engineering and Industrial Base Division. The Combat and Weapon System Engineering and Industrial Base Division efforts are performed at Crane, IN, Louisville, KY and Indian Head, MD. Minor functional transfers will be effected between the activities within the NSWC. The site at Crane as well as the sites at Louisville, KY and Indian Head, MD all remain as operating sites.

d. HM&E R&D and ISE Division. The HM&E R&D and ISE Division is organizationally centered at Carderock, MD. The following actions are required to complete the consolidation.

David Taylor Research Center (DTRC) Detachment Annapolis	
- Initiate downsizing	OCT 91
- Commence transfer of functions	OCT 91
- Operate as a facility	OCT 94
- Continue to downsize as feasible	ONGOING

Naval Ship Systems Engineering Station (NAVSSES)	
- Remains as operating site	OCT 91

David Taylor Research Center (DTRC)	
- Become center of Division	OCT 91

3. NAVAL UNDERSEA WARFARE CENTER

The Naval Undersea Warfare Center will be established on or before 1 October 1991 under the command of a Flag Officer assisted by a Senior Executive Technical Director who are collocated with the Naval Sea Systems Command in Washington, D.C. This action will result in no increase to the overall size of the Washington, D.C. staff. At the same time, the five technical activities that are consolidated into NUWC will be disestablished as separate reporting activities and restructured as integral components of NUWC with the goal of minimizing overhead and infrastructure. The components of NUWC will be organized into two divisions.

a. Combat and Weapon Systems Division. Combat and Weapon Systems Division efforts are centered at Newport, RI. The following actions are required to complete the consolidation.

Trident Command & Control Systems Maintenance Activity (TRICCSMA)	
- Transfer functions to Newport	OCT 91
- Merge with NUWC Newport	OCT 91

Naval Underwater Systems Center (NUSC) Det New London	
- Commence transfer of functions to Newport	OCT 91
- Operate as a facility	JAN 94
- Continue to downsize as feasible	ONGOING

Naval Sea Combat Systems Engineering Station (NSCSES)	
- Organizationally align with NUWC Newport	OCT 91
- Commence transfer of functions	OCT 91
- Downsize to match decreasing workload	OCT 91
- Remain as an operating site	

Naval Underwater Systems Center (NUSC)	
- Become center for Combat and Weapon Systems Division	OCT 91

b. Weapon Systems ISE Division. The Weapon System ISE Division and Industrial Base efforts are centered at Keyport, WA.

Naval Undersea Warfare Engineering Station (NUWES)	
- Become center for Weapons Systems ISE Division	OCT 91

4. NAVAL COMMAND, CONTROL AND OCEAN SURVEILLANCE CENTER

The Naval Command, Control and Ocean Surveillance Center will be established on or before 1 October 1991 under the command of a Flag Officer assisted by a Senior Executive Technical Director who are located at Pt. Loma, San Diego, CA. At the same time, the eleven technical activities that are consolidated into the NCCOSC will be disestablished as separate reporting activities and restructured as integral components of NCCOSC with the goal of minimizing overhead and infrastructure. NCCOSC is organized into three major directorates.

a. RDT&E Directorate. The RDT&E Directorate, centered at Pt. Loma, San Diego, CA, is collocated with NCCOSC and has facilities at Warminster, PA. The following actions are required to complete the consolidation.

Fleet Combat Direction Systems Support Activity (FCDSSA)	
- Commence transfer of functions	OCT 91
- Merge FCDSSA with NCCOSC San Diego	JAN 92
Naval Space Systems Activity (NSSA)	
- Commence transfer of functions	OCT 91
- Close NSSA	APR 92
Naval Ocean Systems Center (NOSC) Detachment Hawaii	
- Commence Transfer of functions	JAN 92
- Close NOSC Det HI	OCT 93
Naval Ocean Systems Center (NOSC)	
- Commence transfer of functions to other centers	OCT 91
- Become the core of the RDT&E Directorate	
- Become the core of the West Coast ISE Directorate	
Navigation Facilities, Warminster, PA	
- Accept custody from NAWC	OCT 92

b. West Coast ISE Directorate. The West Coast ISE Directorate, centered at Pt. Loma, San Diego, CA, is collocated with the RDT&E Directorate and NCCOSC, and has an operating site at Pearl Harbor, HI. The following actions are required to complete consolidation.

Naval Electronic Systems Engineering Center (NESEC), San Diego	
- Commence transfer of functions	OCT 91
- Transfer remaining functions	OCT 92
- Close NESEC, San Diego	OCT 94
Naval Electronic Systems Engineering Center (NESEC), Vallejo	
- Commence transfer of functions	OCT 91
- Transfer remaining functions	OCT 92
- Close NESEC, Vallejo	MAR 95
Naval Electronics Engineering Activity, Pacific (NEEACT PAC)	
- Retain as operating site	

c. East Coast ISE Directorate. The East Coast ISE Directorate is solely located at Portsmouth, VA. The following actions are required to complete consolidation.

Naval Electronic Systems Engineering Center (NESEC), Charleston

- Commence transfer of functions	OCT 91
- Transfer remaining functions	OCT 92
- Close NESEC, Charleston	OCT 94

Naval Electronic Systems Engineering Activity (NESEA)

- Commence transfer of functions	OCT 91
- Transfer remaining functions	OCT 92
- Close NESEA / transfer custody to NAWC	JAN 95

Naval Electronic Systems Security Engineering Center (NESSEC)

- Commence transfer of functions	OCT 91
- Transfer remaining functions	OCT 92
- Close NESSEC	JAN 94

Naval Electronic Systems Engineering Center (NESEC), Portsmouth
- Become center for East Coast ISE Directorate

5. NAVAL RESEARCH LABORATORY

The Naval Oceanographic and Atmospheric Research Laboratory (NOARL) will be disestablished and consolidated into the Naval Research Laboratory on or before 1 October 1991. The NRL will continue to be commanded by a Captain assisted by a Senior Executive Director of Research, both of whom are located at the Laboratory's main site in Washington, D.C. With this merger, the four existing directorates at NOARL and the five directorates at NRL will be integrated into five restructured corporate directorates. The plan achieves overhead reductions associated with the former NOARL, and includes some deliberate functional moves among the operating sites to facilitate the establishment of technical centers of excellence. Nevertheless, the net employment change at any one location resulting from this consolidation will be small.

D. OVERSIGHT STRUCTURE.

There are two levels of oversight of the DON's RDT&E facilities. They are the Navy Laboratory/Center Oversight Council and the Navy Laboratory/Center Commanders Group.

1. NAVY LABORATORY/CENTER OVERSIGHT COUNCIL (NLCOC). A Navy Laboratory/Center Oversight Council will be established to provide the corporate, Department of the Navy oversight of the entire RDT&E facility structure. The membership is as follows:

CORE MEMBERS	**MEMBERS AT LARGE**
ASN(RD&A)	COMNAVSEA, COMNAVAIR, COMSPAWAR, CNR
VCNO	ASN(FM), ASN(M&RA), ASN(I&E)
ACMC	OGC
	CG,MCRDAC
	OP-091

The NLCOC will be chartered to:

- Preclude mission and investment duplication within the Center/Corporate Laboratory structure.
- Establish a single, strategic corporate vision for the Centers and Corporate Laboratory.
- Resolve issues among the Centers/Corporate Laboratory.

2. NAVY LABORATORY/CENTER COMMANDERS GROUP (NLCCG)

The Navy Laboratory/Center Commanders Group will be established and formally chartered to review and coordinate the functioning of the Centers/Corporate Laboratory. The chair and support staff to the group will rotate annually among the members. The membership is as follows:

MEMBERS

Commanders and Technical Directors of
  Naval Air Warfare Center
  Naval Undersea Warfare Center
  Naval Surface Warfare Center
  Naval Command, Control and Ocean Surveillance Center

Commanding Officer and Director of Research of
  Naval Research Laboratory

The NLCCG will be chartered to:

- Identify and prevent unwarranted duplication across laboratory/center boundaries
- Integrate MILCON and Capital Investment Plans
- Review annual business plans for all Centers/Lab
- Serve as a forum to air and resolve issues
- Ensure technical quality and preserve balance
- Facilitate Interservice Reliance and Laboratory Demonstration Program participation

E. PENDING ISSUES.

There are a number of issues that are still under study and development by the RDT&E Facilities Consolidation Working Group. These issues deal primarily with the fine details of implementing the consolidation plan. More information will be provided as it becomes available.

1. FINANCIAL SYSTEM. The RDT&E and ISE facilities are currently managed under a variety of financial systems. A special working group under the Comptroller of the Navy is devising a financial system or systems for the Centers and Corporate Laboratory that will meet their needs while providing an appropriate level of compatibility.

2. PERSONNEL ACTIONS. The consolidation will require a number of personnel relocations and the Congressionally mandated personnel reductions may result in Reduction-in-Force (RIF) actions at some locations. A special working group under ASN (Manpower and Reserve Affairs) is developing guidelines and plans for managing these relocations and reductions. This working group is also addressing a number of other personnel issues, including the impact of the current Department of Defense hiring freeze and the Ethics Bill.

3. PROCUREMENT ISSUES. The consolidation combines a number of commands under centralized management. As a result, the designation of the Head of Contracting Authority (HCA), the identification of procurement channels, and supporting procurement infrastructure must be clarified. A special working group under ASN(RD&A) Acquisition Policy, Integrity and Accountability (API&A) is identifying and reviewing alternative solutions for these issues.

[Whereupon, at 11:05 a.m., the subcommittee adjourned.]

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